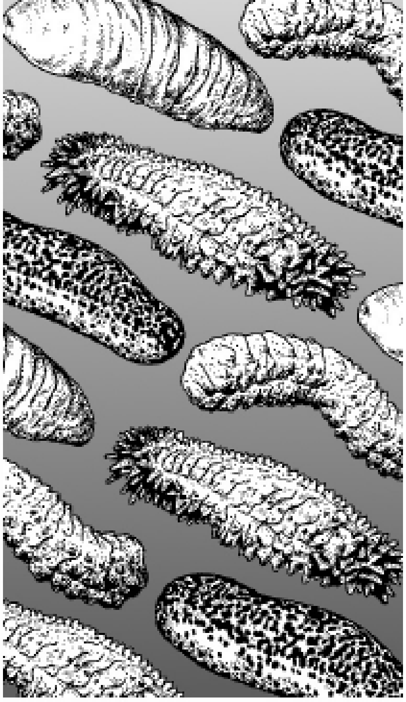

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Inside this issue

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Editorial

Welcome to the 26th issue of the SPC *Beche-de-mer Information Bulletin*, which begins with a pilot study conducted in Samoa by Eriksson et al. (p. 2) on the regeneration of *Stichopus horrens,* a species whose viscera are locally consumed. The authors suggest that such research will help to understand *S. horrens* organ regeneration in the field and prove valuable for future management of this fishery. An article by Leeworthy and Skewes (p. 5) details a new method for conducting underwater visual censuses, referred to as the hip-chain transect. A recent survey by Mulochau et al. (p. 7) shows that some remote reefs of the Indian Ocean near Mayotte have very poor holothurian fauna, which could be a sign of overexploitation. Ahmed and Lawrence (p. 14) relate how four years after a ban on the sea cucumber fishery in Egypt, some commercial species are showing signs of returning, although there is no evidence of stock recovery. The Seychelles' sea cucumber fishery is expanding rapidly and requires management. Aumeeruddy and Conand present new data (p. 19) on the dried products of five marketed species. The authors hope that this information will be useful for describing species characteristics and for establishing market grades. Leeworthy contributes another article, this one on the application of the Two-Term Local Quadrat Variance Analysis, with data obtained by using conventional underwater visual census of *Actinopyga echinites* (p. 26). Hirimuthugoda et al. (p. 31) pursue their research on probiotic yeasts with phytase activity, identified from the gastrointestinal tract of sea cucumbers.

We continue to publish observations on sea cucumber natural spawnings, fission and recruitment, so don't hesitate to submit your field or laboratory observations. In this issue, F.A. Abdel Razek et al. (p. 33) describe a new case of induced fission in *Holothuria arenicola*.

Please note that instructions have been prepared to assist authors and editors in writing and submitting papers for this publication. They are available at: http://www.spc.int/coastfish/news/SIG-instructions.pdf

As usual, this and all previous issues of the bulletin are available in PDF format on SPC's website at: http://www.spc.int/coastfish/News/BDM/bdm.htm

I would like to remind readers that all articles and abstracts published in the bulletin can be found in a database that has been developed by SPC's Fisheries Information Section. This database includes more than 600 article and abstract titles that can be searched by title, author name(s), scientific name, region or country. Each search result is presented with a hyperlink that allows downloading in PDF format. The database is available on SPC's website at: http://www.spc.int/coastfish/news/search_bdm.asp.

Finally, I'd like to draw your attention to a joint project between different partners of the Aspidochirote Working Group. You will find more information on this project at: http://www.uog.edu/marinelab/peetcukes/index.html

Chantal Conand

A pilot study to investigate the survival of *Stichopus horrens* after viscera harvest in Samoa

H. Eriksson[1], K. Friedman[2], A. Solofa[3] and A.T. Mulipola[3]

Introduction

In Samoa, sea cucumbers are harvested for subsistence and artisanal purposes. Four species are targeted by local fishers: peanutfish, *Stichopus horrens* [4] (local name *sea*); brown sandfish, *Bohadschia vitiensis;* lollyfish, *Holothuria atra*; and the leopard or tigerfish, *Bohadschia argus*. *S. horrens* is the most sought after species and is fished for its viscera (generally the intestine, but also respiratory tree and gonads). The viscera product is removed from live animals and consumed raw, while processed animals are returned to the water alive. The viscera product from *sea* is placed — along with body wall strips from other sea cucumbers — in bottles filled with seawater and sold at local markets and along the roadside (Figs. 1 and 2). This species is also fished in other parts the Pacific, such as Tonga (K. Friedman, pers obs). *Sea* supports a "gamat water"[5] industry in Malaysia (Baine and Forbes 1998; Baine and Choo 1999), where its use as a traditional nutrition and drug agent is well documented (Ridzwan et al. 2003; Hawa et al. 1999).

Some fishermen believe that animals survive the harvesting procedure and that returning processed *sea* to the ocean allows the animals to be harvested again after they regenerate their internal organs. The animals' survival and the possible regeneration of their viscera after cutting has attracted the attention of researchers, but few experiments have been conducted on potential survival and regeneration rates for animals harvested in the traditional fisheries in the Pacific (Lambeth 2000). Some studies show that intestinal regeneration is possible among holothurians (e.g. Quiñoñes et al. 2002; Mashanov et al. 2005), as well as gonadal regeneration (Drumm and Loneragan 2005). Studies on another species (e.g. *Holothuria parvula*) suggest that full organ regeneration (following self-induced fission) may take up to a year (Emson and Mladenov 1987). It is not known if *S. horrens* survives the harvesting process in Samoa, and even less is known about whether regrowth of its internal organs would allow re-harvesting for the collection of more viscera product. The possibility that animals survive the removal of their viscera consequently provides an exciting possibility for the management of a declining fishery, where a rotational fishing scheme could boost productivity.

Figure 1. The *S. horrens* (*sea*) viscera product.

Figure 2. Bottles of sea cucumber raw product: the brown mass is viscera from *S. horrens* and the white mass is from the body wall of *B. vitiensis*.

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4. In the past, this species has often been referred to as *Stichopus herrmanni*, and nomenclature is currently under further review.
5. *Gamat* water is boiled coelomic fluid. It is taken orally for certain ailments.

Fishing for *sea*

In Samoa, *sea* are collected at night from a canoe using an underwater torch and a mask and snorkel (or goggles). The *sea* are kept in the bottom of the canoe in water (see Fig. 3) and brought back to shore after fishing where they are placed into buckets and held until processing. Fishing trips usually last around three hours. One-third of each bucket is filled with animals and then topped up with fresh seawater. Keeping the *sea* in buckets allows the animals to empty their intestines of sand, which makes the viscera product more edible. In general, animals are left in buckets for two to five hours, although the time varies between sites and fishermen. The *sea* is then processed by cutting a slit in the side of the animal with a knife (Fig. 4) to expose the viscera, and the intestine is checked for sand before being placed in a glass bottle. After the animal has been cut and emptied of its viscera, it is discarded into a separate bucket that is filled with a small amount of seawater. It seems that less care is taken of these animals after processing. Processed animals are returned to the ocean, close to the shoreline, which is not the preferred habitat of *sea* in most fishing locations. Even if the animals survive the cutting procedure, they may stand less chance of survival after being returned to the ocean, away from their preferred habitat. In villages where fishing was observed, the nearshore areas had high sediment loading, were exposed to wave action, or had a very high terrestrial influence (including runoff of village wastes).

Figure 3. *Sea* fisher with live product in his canoe.

Pilot study

Following the PROCFish/C survey in Samoa, a pilot study was set up to learn about what happens to *S. horrens* after they have been cut and emptied of viscera. The authors believe that post processing handling of *S. horrens* could play a vital role in the future management of the fishery. The study was performed as a small-scale survival project and attempted to determine the survival rate of *S. horrens* after processing. The study was conducted from 8–12 December 2005 in the village of Toamua, just west of Apia.

Three hours were spent fishing from 19:30 to 22:30, and during this time 23 *S. horrens* individuals were caught. The catch was brought back to shore and left overnight (8 h) in a bucket. In the morning, the animals were cut and processed by a local fisher. These processed animals were placed in cages, three cages with six animals each, and one cage of five animals in a nearshore area (where the animals were usually returned). Two to three large rocks were placed inside each cage to hold it down; these rocks also provided shelter for the animals. On the following day, the animals were checked for survival and the possible heal of their cut. After 24 hours in the cages, 13 animals were still alive: nine had healed their cut, three had almost healed, and one remained in a similar condition to when it was processed. After four days, four of the animals were cut open to check for possible regrowth of viscera. No viscera

Figure 4. Cutting *S. horrens* for its viscera.

regrowth was noted for any of the animals. In spite of its small scale this study still reveals a rough survival estimate of about 50% after the first 24 hours in the cages, and that out of these survivors the majority had completely healed their cut. These findings are in agreement with a similar study of *Holothuria leucospilota*, where it was found that incisions in the body wall healed within a few days (Drumm and Loneragan 2005).

Outlook

The authors realise that the experiment was preliminary and wish to draw attention to the failings of this study and highlight what is necessary for future work.

Experience from this pilot study has shown that plastic mesh cages (size: base 450 mm x length 450 mm x height 200 mm, mesh size: 12–17 mm) used to hold post-processed animals may be unsuitable for use as a holding unit, because the mesh size is too large, allowing animals to escape, and the cage itself has an effect on the recovering animals. In a similar study with *H. leucospilota*, cages were lined with 2 mm nylon mesh with excellent survival rates of processed animals (Drumm and Loneragan 2005).

The authors believe that survival may be affected by two factors: processing and the selection of the catch–return area. Handling issues, which include transport and holding procedures, need to be assessed, and returning cut animals to inshore sites or areas of *S. horrens* habitat might also critically affect the survival of processed animals. Further studies would ideally include treatments that assess pre- and post-processing holding times, and the return of processed animals to both nearshore areas (where fishers currently return their catch) and preferred *S. horrens* habitat (where the animals are caught). Some fishers harvest *sea* by day when the animals are typically not feeding; this way, "clean" viscera can be removed immediately. Discards from this fishing activity are done in the vicinity of the collection site. Experiments designed to test the selection of the catch–return area might benefit from this difference in the catch–return method.

Other factors to be considered are post-processing predation and the effects of wave exposure in nearshore areas. More long-term assessments might also suggest the best time to harvest *sea*, and a time period that processed stock should be rested, before they are re-processed.

Summary

This pilot study showed that *S. horrens* can survive the harvesting and processing procedures that are necessary in order to collect viscera. This study also shows that the animals are able to heal their cut, although no further conclusions can be derived from these results. Future studies should address the probability of survival, depending on handling procedures and the catch–return area. The authors believe that such research will increase the understanding of *S. horrens* organ regeneration in the field, and will prove valuable for future management of this fishery.

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The hip-chain transect method for underwater visual census (UVC)

Grant Leeworthy[1] and Tim Skewes[2]

Underwater visual census (UVC) benthic surveys are typically done by laying out rope or lines on the sea bottom. A diver then follows and count species of interest. Such rope transects are slow to deploy and retrieve, limiting the number of transects that can be completed and, therefore, the precision of the survey. Most benthic species have a patchy distribution, meaning that a high number of sites must be surveyed.

Several methods for carrying out UVC surveys without using transect lines have been developed in order to increase the efficiency of sampling. Timed swims (Hart 2006), manta-tows (Moran and De'ath 1992) and flow meters (Conand pers comm. 2007) are very efficient methods, however, all are subject to some uncertainty with regard to transect dimensions, especially transect length.

The hip-chain transect method, which uses a thread-release measuring device, has the advantage of providing an accurate measure of transect length, while also being very efficient because it eliminates the need to lay and retrieve a transect line. The diver lays the transect line as he swims, using a biodegradable cotton thread, with the distance from the point of origin measured as the thread is released. This has the added advantage of allowing access by divers into areas that boats cannot access, due to draught restraints or the presence of navigational hazards.

Using the hip-chain method dramatically increases the number of samples that can be completed during limited (and often expensive) field programmes; this in turn can increase the precision, accuracy and extent of marine surveys. The hip-chain method is an improvement on existing technology and will allow for greater accuracy and a broader focus for future marine survey-based studies.

Description

The hip-chain method relies on a "Chainman" brand thread-release measuring device modified for use in saltwater to measure transect length. The hip-chain device has a reel of biodegradable cotton that goes through a calibrated gear wheel, which measures the distance in meters.

Prior to using the device in saltwater the hip-chain needs to be modified by replacing the spool mechanism with a stainless steel bolt and drilling a hole in the body of the counter to allow for the addition of lubricant (e.g. WD40) to prevent corrosion.

The hip-chain device, pole, tally counter and compass are all assembled with wire, cable ties and/or hose clamps into a sampling assembly. Half of a clipboard is also added in order to hold a data sheet for divers to record habitat, depth, date, time and species counts. A pencil is attached using a leash of twisted tape. Periodic calibration of the hip-chain device is recommended. This can be done on land and is a fairly basic process. An example of a version of the hip-chain sampling assembly used for sampling holothurians is shown in Figure 1.

At the starting point for the transect, the diver ties the cotton thread to a piece of rock or coral at the bottom by means of a small wire stake. As the diver swims along the transect, the hip-chain device accurately measures the distance swum. When the diver reaches the desired transect length, the cotton thread is broken off and left on the bottom to degrade. The diver counts species of interest along the transect using the tally counter. For multiple species assessments, tally counters with up to six banks may be used.

A diver can control transect width by holding a pole in front of him while swimming the transect. The feasible maximum width of a transect is restricted by the field of view available to the diver as determined by water clarity and the increased difficulty in searching and governing boundary effects with distance. A 2 m-wide transect has been used successfully in open substrates, with a narrower, 1.25 m-wide transect used in more cryptic habitats to survey highly abundant species, due to the greater difficulty in obtaining accurate counts in this circumstance.

Because the transect line is laid while the diver is swimming the transect, it is important that the

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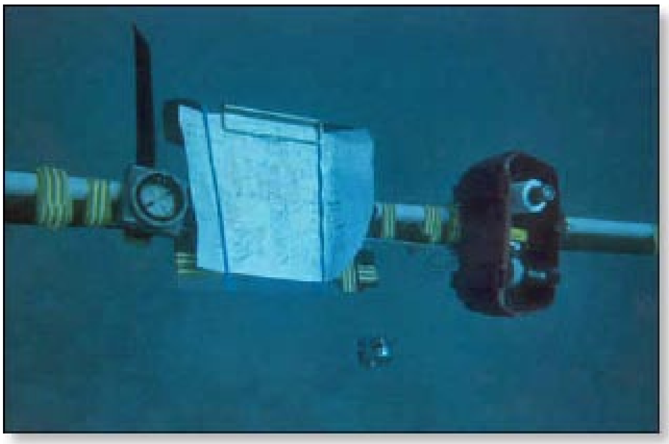

Figure 1. Detail of a hip-chain sampling assembly used to survey holothurians.

transect path is carefully followed to reduce the possibility of bias caused by the diver swimming towards species/objects of interest. This can be achieved by diver training and objective direction-setting techniques, such as the diver swimming the transect according to a predetermined compass bearing. A waterproof compass can be attached to the hip-chain assembly to facilitate this. A discussion of observer-induced bias in transect-based surveys can be found in McGarvey (2006). Boundary effects (animals that traverse the transect boundary on either side of the diver) can be dealt with according to a standard practice (Andrew and Mapstone 1987; Thompson and Mapstone 1997). Again, sufficient diver training is necessary to ensure the boundary effects of inclusions and/or exclusions are adequately addressed.

Acknowledgements

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Sea cucumbers and other echinoderms at Geyser Bank, Mayotte (Indian Ocean)

T. Mulochau[1], C. Conand[2] and J.P. Quod[3]

Introduction

As part of a biodiversity study designed to monitor changes in fisheries resources,[4] we collected echinoderm samples, particularly Holothuridae, from Geyser Bank in Mayotte (Fig. 1). This sampling was the first inventory taken at this bank and little scientific information existed about sea cucumber biodiversity and exploitation in this region (e.g. for Mayotte: Pouget 2004, 2005; Conand et al. 2005; for the Comoros: Samyn et al. 2005). Data on sea cucumbers from Reunion Island (Conand and Mangion 2002) and crown-of-thorns starfish (Emeras et al. 2004) may also be useful. The biodiversity of other echinoderms from the islands in the Mozambique Canal zone is also poorly known and concerns the Glorioso Island reef flats (Vergonzanne 1977).

Geyser Bank is 300 km west of the northernmost tip of Madagascar and 110 km northeast of Mayotte. This bank, which has been fished since the 1990s because of its rich fisheries resources, is part of Mayotte's exclusive economic zone (73,600 km^2) and remains isolated from coastal human pressures.

Worldwide, sea cucumber fisheries are growing, thereby giving rise to overfishing in most tropical Indo-Pacific countries (Conand 1999 and 2004). A lack of data about sea cucumber populations at this bank was the reason behind this current study initiated by the Mayotte Government. The purpose of this work was to make an initial list of the sea cucumber species found and provide mean abundances in the prospected zones.

Materials and methods

Study site

Geyser Bank (surface area of 175 km^2) is in the western Indian Ocean, north of the Mozambique Canal, between Mayotte and the Glorioso Islands (Fig. 1). This coral structure is built on shoals in the open ocean and only certain parts of it can be

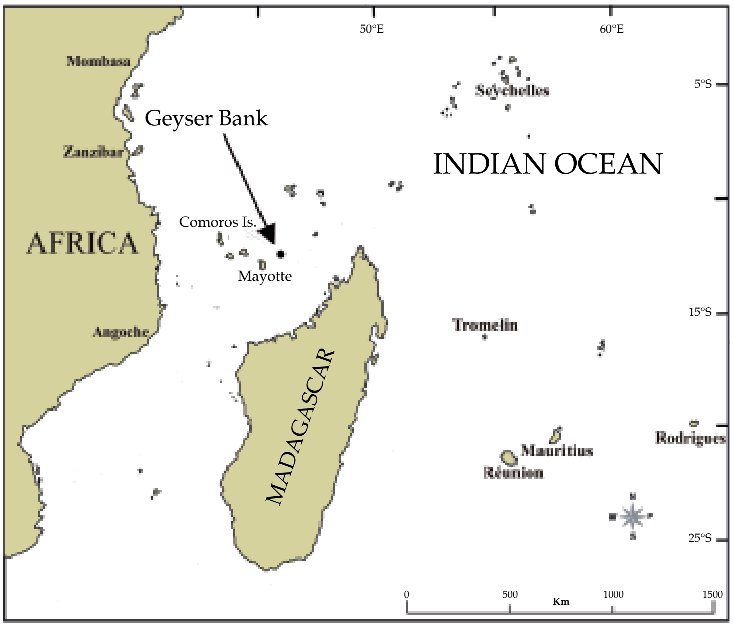

Figure 1. Geyser Bank, north of Mozambique Canal.

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4. This study was commissioned by the Mayotte Direction de l'Agriculture et de la Forêt (DAF) from 4–13 December 2006.

Table 1. Biotopes and biocenoses at the 11 stations sampled at Geyser Bank.

Stations	Depth	Biotope	Biocenose
Station 1 on 05.12.2006 AM	12–18 m	External slope – bottom of slope Hard substrate: 46% Rubble: 34% Sand: 20%	50% coral cover 39% seaweed cover (including 76% calcareous algae) 11% other organisms
Station 2 on 06.12.2006 AM	12–18 m	Outer slope– Area along the edge of the reef Hard substrate: 84% Rubble: 34% Sand: 12%	67% coral cover 30% seaweed cover (including 67% standing seaweed) 3% other organisms
Station 3 on 06.12.2006 PM	12–18 m	Outer slope – bottom of slope Hard substrates: 64% Rubble : 21% Sand : 15%	40% coral cover 51% seaweed cover (including 82% calcareous algae) 9% other organisms
Station 4 on 07.12.2006 AM	12–18 m	Outer slope – bottom of slope Hard substrate: 63% Rubble: 26% Sand: 11%	68% coral cover 32% seaweed cover (including 39% calcareous algae and 39% standing seaweed)
Station 5 on 07.12.2006 PM	12–18 m	Outer slope – bottom of slope Hard substrate: 70% Rubble: 20% Sand: 10%	69% coral cover 28% seaweed cover (including 62% calcareous algae)
Station 6 on 08.12.06 AM	12–18 m	Coral heads on sandy bottoms Hard substrate: 82% Rubble : 14% Sand : 4%	21% coral cover 79% seaweed cover (including 98% seaweed bed)
Station 7 on 08.12.06 PM	15 m	Thallassodendron sea grass bed and coral heads of sandy-rubble bottoms Sand : 50%	50% seagrass cover
Station 8 on 09.12.06 AM	12 – 18 m	Outer slope – bottom of slope Hard substrate: 66% Rubble: 22% Sand: 12%	39% coral cover 61% seaweed cover (including 60% calcareous algae)
Station 9 on 09.12.06 PM	12–18 m	Inner slope – Foot of slope Hard substrate: 84% Rubble: 13% Sand: 3%	68% coral cover 31% seaweed cover (including 88% calcareous algae)
Station 10 on 10.12.06 AM	12–18 m	Outer slope – Along the edges of the reef Hard substrate: 76% Rubble: 20% Sand: 4%	47% coral cover 53% seaweed cover (including 72% calcareous algae)
Station 11 on 10.12.06 PM	9 m	Lagoon Hard substrate: 88% Rubble: 12%	46% coral cover 54% seaweed cover (including 75% standing seaweed)

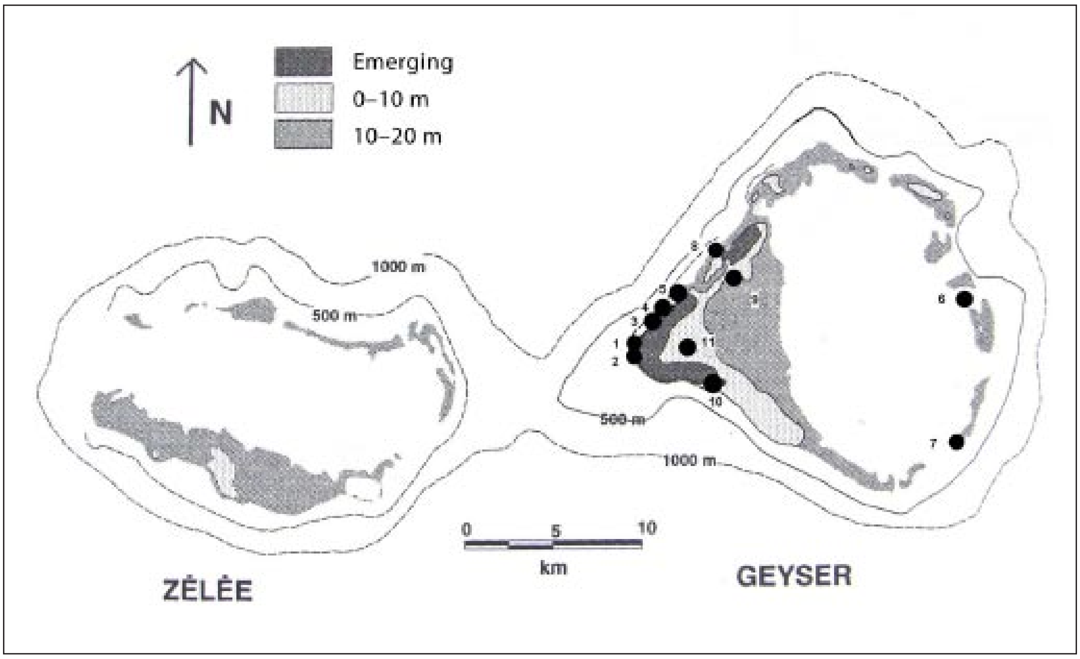

Figure 2. Location of the 11 study stations at Geyser Bank.

seen at the surface during low tide. Several habitats with differing geomorphologic criteria were sampled from 11 stations (Fig. 2 and Table 1): the external and internal slopes of the outlying subsurface reefs, the external slope of the outlying underwater reef, the coral heads, and the sedimentary terrace bottoms.

Sampling technique

Sampling was done using underwater dives at depths of between 10 and 20 meters. Nine divers carried out 40 hours of diving in order to count and photograph the different species. The total surface area inventoried was 28,600 m^2 (i.e. about 0.015% of the bank's overall surface area). The estimated surface area for each station sampled covered about 2600 m^2: 750 m^2 for the "fish" transect (500 m^2 for the transect and 250 m^2 outside) and 1850 m^2 for the fixed "fish" points. Sampling at the 11 stations consisted of systematically inventorying the reef's surface area, cavities, boulders of dead coral that could be turned over, and the sediment.

Results

Total sea cucumber density over the surveyed area was 18 specimens for 28,600 m^2 (about 5 specimens ha^{-1}). Seven species of sea cucumbers were represented by 18 specimens. Table 2 shows the relative abundance and frequency of the various species.

The two most abundant species were *Thelenota ananas* (Fig. 3C), with a relative abundance of 39%, and *Bohadschia subrubra* (Fig. 3B), at 28%. These were also the two species with the highest frequency of observation at 54.5% and 36%, respectively. *Thelenota ananas* had a mean density of 2 specimens ha^{-1}.

Table 2. Relative abundance* of each sea cucumber species at 11 stations surveyed at Geyser Bank and the frequency of observation** for each species.

Species	Relative abundance	Frequency of observation
Thelenota ananas	39.0%	54.5%
Bohadschia subrubra	28.0%	36.0%
Actinopyga obesa	11.0%	18.0%
Actinopyga mauritiana	5.5%	1.0%
Bohadschia sp.	5.5%	1.0%
Holothuria nobilis	5.5%	1.0%
Holothuria sp.	5.5%	1.0%

* Expressed as the number of specimens per species/total number of sea cucumbers.
** Expressed as the number of stations where the species was found /total number of stations.

Actinopyga obesa (Fig. 3D) was relatively rare with a relative abundance of 11% and a frequency of observation of 18%.

All other species — *Actinopyga mauritiana* (Fig. 3A), *Bohadschia* sp. (Fig. 3E), *Holothuria nobilis* (Fig. 3F), and *Holothuria* sp. — were only seen once at a single station and can therefore be considered as rare at Geyser Bank.

Stations 1 and 8, outer slope stations with an average level of coral cover (Table 1), are the stations where species richness and abundance were the highest with three species each and seven specimens (Table 3). Stations 2, 3, 5, 6, 9 and 10 had lower species richness with one or two species. No sea cucumbers were recorded at Stations 4, 7 and 11. Station 4, which had the same biotope and biocenosis as Station 9), was an inner slope station with a high level of coral cover. Station 7, a seagrass bed station on a sedimentary bottom and Station 11 was a shallow coral head station with average coral cover (Tables 1 and 3).

Other echinoderms found included 13 Echinidae species, 4 Ophiuridae species, 3 Asteridae species and 3 Crinoidae species (Table 3)

Table 3. Abundance of the various echinoderm species sampled by station at Geyser Bank (total surface area prospected: 28,600 m^2) during 40 hours of diving (4.5 h diver^{-1})

Stations (St)	St 1	St 2	St 3	St 4	St 5	St 6	St 7	St 8	St 9	St 10	St 11
Holothuridae (7 species)											
Thelenota ananas	1	1			2	1		1	1		
Bohadschia subrubra	1		1			1		2			
Actinopyga mauritiana			1								
Actinopyga obesa	1							1			
Holothuria nobilis									1		
Bohadschia sp.		1									
Holothuroidea sp.										1	
Echinidae (13 species)											
Echinothrix calamaris	1				2			1			
Echinothrix diadema		1			1						
Diadema savignyi					2						
Diadema setosum					2						
Eucidaris metularia			1								
Prionocidaris verticillata									1		
Echinostrephus aciculatus	2	1	1		10	1		50	1	1	
Chondrocidoris gigantea											1
Metalia sp.											1
Clypeaster sp.									1		
Cassiduloida or *Spatangoida* sp. 1						50					
Cassiduloida or *Spatangoida* sp. 2							50				
Heterocentrus mammillatus			1		5						
Asteridae (3 species)											
Fromia milleporella	1						1	1			
Leiaster coriaceus								1			
Acanthaster planci										40	
Ophiuridae (4 species)											
Ophiarachnella gorgonia						1					
Ophiocoma erinaceus										1	
Ophiotrix sp. aff *vigelandi*										1	
Ophiotrix sp.					1						
Crinoidae (3 species)											
Tropiometra carinata			1								
Dorometra mauritiana					2						
Dorometra sp.										1	

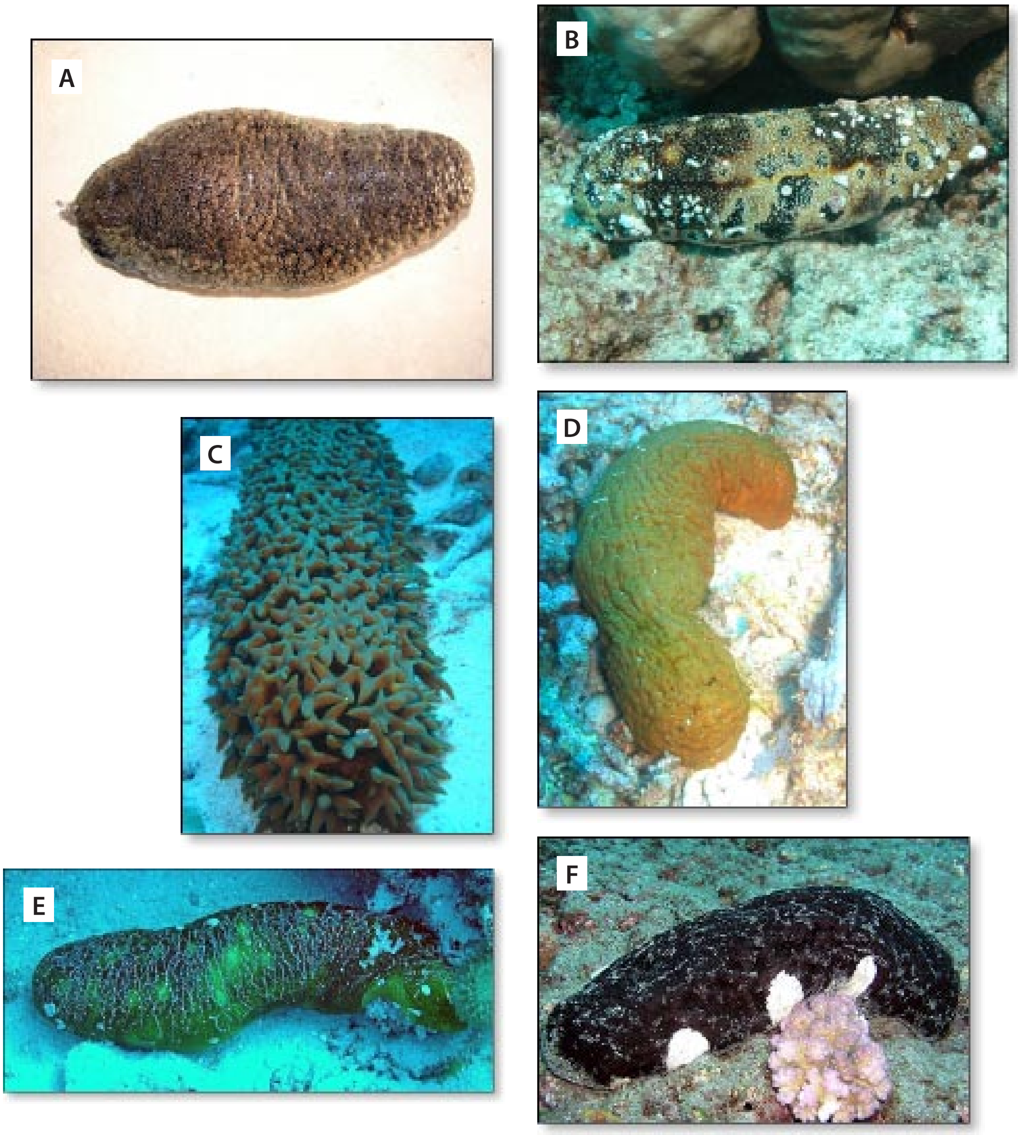

Figure 3. A few large sea cucumber species sampled at Geyser Bank (Mayotte).
A: *Actinopyga mauritiana*; B: *Bohadschia subrubra*; C: *Thelenota ananas*;
D: *Actinopyga obesa*; E: *Bohadschia* sp.; *Holothuria nobilis*

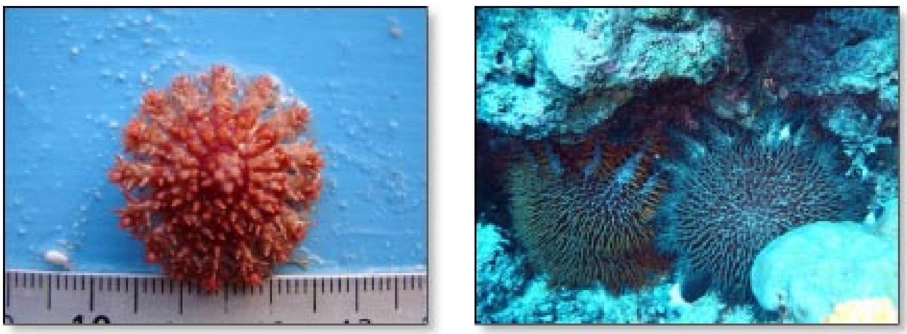

Figure 4. *Acanthaster planci* at Station 10 at Geyser Bank

Some 13 Echinidae species were sampled for this category from a total of 188 specimens. Their relative abundance and frequency are given in Table 4.

Three Asteridae species represented by 3 *Fromia milleporella* were found at Stations 1, 7 and 8; 1 *Leiaster coriaceus* at Station 8; and a cluster of about 20 specimens per 100 m^2 of *Acanthaster planci* over an estimated surface area of 200 m^2 at Station 10 on the outlying underwater reef flat. The mean size of the *Acanthaster planci* was 40 cm. We also found an *Acanthaster* juvenile at the same site (Fig. 4).

Finally, four Ophiuridae species and three Crinoidae species were also observed.

Discussion

Sea cucumber diversity observed in this survey (7 species) was very low compared with other sites studied in the Comoros (Samyn et al. 2005), Mayotte (27 species Conand et al. 2005), and at Reunion Island (Conand and Mangion 2002). In particular, no species were found on the reef flats during a supplementary sampling carried out over a surface area of about 5000 m^2, which suggests either a lack of a favourable biotopes or, more likely, harvesting by fishers since Geyser Bank may be fished on a sporadic basis. In fact, a boat with five divers was observed in 2004.

Sea cucumber density at the surveyed surface area also seems to be very low in comparison with certain areas at other Indian Ocean islands. These data are mainly linked to reef flats such as the fringing reef flats in Reunion Island where figures often reach several specimens per m^2 (Conand and Mangion, 2002) and on Mayotte, where densities are lower. This scarcity may be explained by a lack of favourable biotopes due to the concentration of organic matter, a prerequisite for sea cucumber feeding, is low at Geyser Bank because it is isolated from supplemental coastal organic matter.

Thelenota ananas, a species of commercial interest, considered to be a rare on the outer flat of the fringing reef in Mayotte with 4 specimens ha^{-1} (Pouget 2005), only had densities here of some 2 specimens ha^{-1}.

Table 4. Relative abundance of each Echinidae species (number of specimens for one species/total number of urchins) at 11 stations at Geyser Bank (total surface area surveyed: 28,600 m^2) and frequency of observation for each species (number of stations where the species was observed/total number of stations).

Species	Relative abundance	Frequency of observation
Echinothrix calamaris	1.5%	27%
Echinothrix diadema	1.0%	18%
Diadema savignyi	1.0%	1%
Diadema setosum	1.0%	1%
Eucidaris metularia	0.5%	1%
Prionocidaris verticillata	0.5%	1%
Echinostrophus aciculatus	36.0%	73%
Chondrocidoris gigantea	0.5%	1%
Metalia sp.	0.5%	1%
Clypeaster sp.	0.5%	1%
Cassiduloida or *Spatangoida* sp 1	27.0%	1%
Cassiduloida or *Spatangoida* sp 2	27.0%	1%
Heterocentrus mammillatus	3.0%	18%

Sampling methods could be improved to make it possible to record smaller species but large-sized species could not be overlooked. Night dives would also have allowed sampling of other species.

Other echinoderm populations observed during this study also seemed to have low levels of diversity and were generally not very abundant. The lack of any *Acanthaster* at most stations was interesting, however a large group (Conand 2001) was observed along with one juvenile at Station 10. At Reunion Island, the largest clusters did not exceed three to four species on average, per 30-minute dive (Emeras et al. 2004). It is important to verify at a later time what has happened with the *Acanthaster* population at Station 10 and its effects on the coral.

Acknowledgements

We thank Mr R. Rolland and Mayotte Direction de l'Agriculture et de la Forêt (DAF) for making this study possible. We also thank Professors M. Jangoux, C. De Ridder of the Université Libre de Bruxelles, and Dr I. Eeckaut of the Université de Mons-Hainaut for their assistance in identifying the various echinoderm categories.

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The status of commercial sea cucumbers from Egypt's northern Red Sea Coast

M.I. Ahmed[1] and A.J. Lawrence[1]

Abstract

Following an initial study in which evidence indicated that commercial sea cucumber stocks in the Egyptian Red Sea had been significantly overexploited by the development of a commercial fishery, this study aimed to re-visit some of the sites of the original study to determine whether there was any evidence of stock recovery following the 2003 fishery ban adopted by the Red Sea Governorate and other authorities. Four sites were assessed using the belt transect method applied in the original study. The sites were selected based on their accessibility, initial stock levels, and degree of exploitation. A further six sites were assessed visually to determine the presence or absence of commercial species. Evidence from the current study indicates that four years after the ban on the fishery, there is evidence that some commercial species are returning to some of the sites, but there is no evidence of stock recovery.

Introduction

The sea cucumber fishery is characterized by boom and bust cycles, with biological overexploitation often occurring before economic overexploitation (Preston 1993; Conand 1997). Overharvesting is a worldwide phenomenon (Conand 2000) and recovery of depleted populations is slow and sporadic (Kinch 2002). In Torres Strait, for example, the *H. scabra* fishery has not recovered from heavy depletion in 1996, even though the fishery has been closed since 1998 (Skewes et al. 2000).

After the depletion of sea cucumber fisheries in other parts of the world (Kinch 2002; Lovatelli et al. 2004), a small-scale sea cucumber fishery began in Egypt in 1998 on the southern part of Red Sea coast. By 2000, the sea cucumber fishery in Egypt had increased greatly as a result of the high demand for beche-de-mer and the high prices paid for it (Lawrence et al. 2004).

In Egypt, two methods were used to harvest sea cucumbers. In the south, sea cucumber were harvested with a benthic trawl. Initially considered as bycatch, sea cucumbers were later specifically targeted and subjected to heavy trawling activity. In the central part of the Egyptian Red Sea and the Gulf of Aqaba, collecting was done by scuba diving. Some species were also harvested by hand at low tide on the reef flats (Lawrence et al. 2004).

In April 2000, the Red Sea Governorate banned sea cucumber fishing in the coastal area under its jurisdiction. However, the neighbouring Suez Governorate continued with an open fishery. This led to further depletion of stocks in the Red Sea as a whole, and added to the difficulty of policing Red Sea Governorate coastal areas (Lawrence et al. 2004). Furthermore, the ban led to the development of a large illegal fishery in the region under the jurisdiction of the Red Sea Governorate. This illegal fishery continued unabated, both as a result of the low level of patrolling (and difficulty of policing such a large area) and the development of a conflict between the Egyptian Environmental Affair Agency (EEAA), which wanted to limit the fishery, and the Ministry of Agriculture, Department of Fisheries, which aimed to exploit the resource to its maximum (Ahmed 2006).

Despite the efforts of the EEAA and other environmental agencies to retain the ban, the sea cucumber fishery was re-opened in 2002 and licenses to collect sea cucumbers were issued: 52 boat licenses and 100 individual fishermen licenses. Due to further depletion of commercial holothurians, a meeting was held in March 2003. This meeting was attended by representatives from the EEAA, Ministry of Agriculture, and the Red Sea Governorate. This resulted in a second ban on the fishery, which was implemented in December 2003. In this instance, however, the ban applied to the whole of Egypt and had the support of all relevant agencies (Ahmed 2006).

Since the original survey by Lawrence et al. (2004) and the 2003 ban on the fishery, there has been no follow-up monitoring of sea cucumber stocks to

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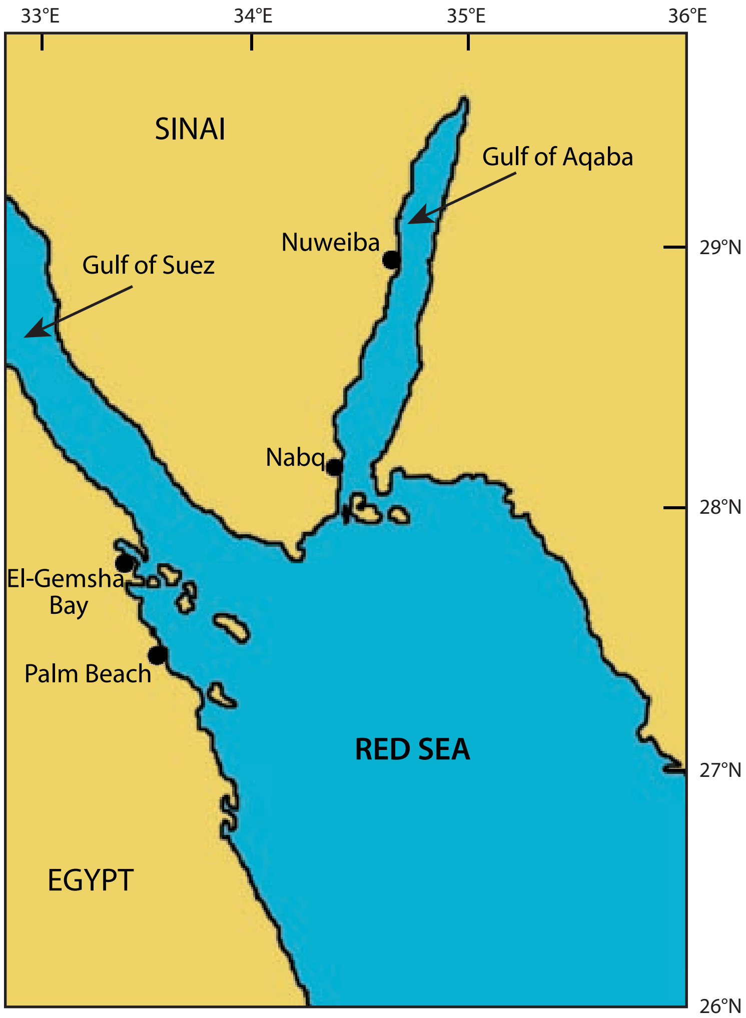

Figure 1. The four sites selected for re-survey of commercial sea cucumber stocks along the Red Sea coast and Gulf of Aqaba.

determine whether there has been any recovery, particularly of commercial species. The aim of this small study was, therefore, to re-visit some of the sites surveyed in the original stock assessment to assess whether there has been any recovery in stocks since the 2003 ban.

Materials and methods

Four sites were selected to be re-surveyed for signs of sea cucumber recovery. Two sites were in the Gulf of Aqaba (Nabq protected area and Nuweiba) and two (El-Gemsha Bay and Palm Beach) were on the Red Sea coast (Fig. 1). These sites were characterized by a relatively high density of certain commercial sea cucumber species in 2002, followed by later overexploitation.

A belt transect method — described in the original survey by Lawrence et al. 2004 — was repeated in the current study to determine the composition, density and abundance of holothurians at each site. A 50-m line was laid parallel to the shore at depths of 5–10 m, 10–20 m and 20–30 m. All sea cucumber species occurring within the 50-m belt transect were counted and identified whenever possible.

In addition, six other sites were re-visited in order to collect samples for a separate study. These six sites were on the islands offshore from Hurghada on the Egypt's Red Sea coast, south of Palm Beach. While quantitative data were not collected at these sites, the species of sea cucumber found were noted and compared with those observed in the original survey.

Data collected in the current study are compared with data collected from each site in the original survey.

Results

Results from the current study indicate that at the four empirically surveyed sites, there has been very

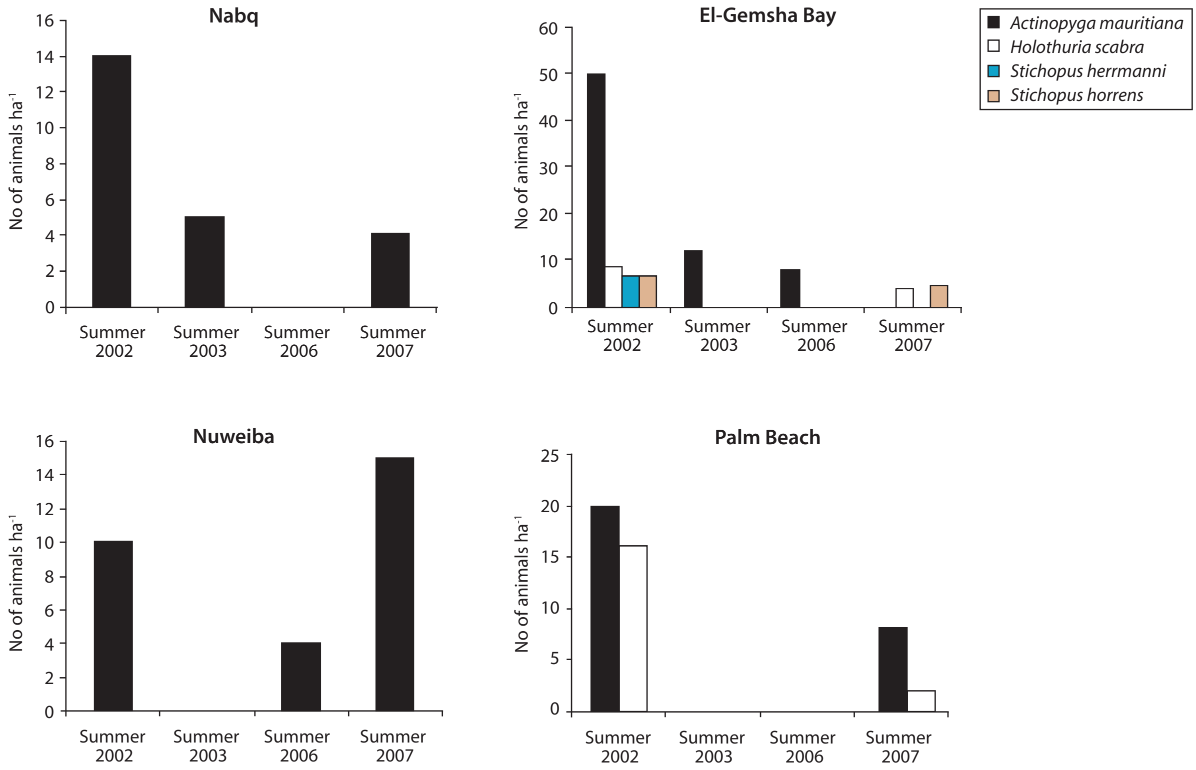

Figure 2. Density (i.e. number of animals ha^{-1}) of commercial holothurian species found at four sites along Egypt's Red Sea coast.

limited recovery of commercial species (Fig. 2). At Nabq in the Gulf of Aqaba, *A. mauritiana* is still the only commercial species present. Its numbers were reduced from 14 ha^{-1} in 2002 to 0 in 2006. Animals have again been found in 2007 but only at a density of 3 ha^{-1}. Therefore, at this stage it is not possible to confirm that *A. mauritiana* is showing real recovery from its 2002 status. However, at Nuweiba there may be some recovery of *A. mauritiana*. Numbers there fell from 10 ha^{-1} in 2002 to 0 by 2003 but appear to have recovered to 2002 figures by 2007. However, no other commercial species were found at the site.

There were also mixed results at the Red Sea coast sites. At El-Gemsha Bay there appears to have been no recovery in *A. mauritiana* numbers. However, *S. herrmanni* and *S. horrens*, which appeared to have been lost from the area by 2003, seem to have returned to the site by 2007. A similar trend is apparent at Palm Beach. Both *A. mauritiana* and *H. scabra* appeared to have been fished from the site by 2003 but have returned by 2007 although their numbers are much lower than those recorded in 2002.

Given the limited nature of the data from the four sites, only El-Gemsha Bay has shown a significant difference in the number of commercial species present between years (chi-square = 21.88, $P < 0.05$). This is most likely due to the loss and subsequent return of *S. herrmanni* and *S. horrens* between 2002 and 2007. In addition, *A. mauritiana* was the only species to show a significant difference in numbers between years within sites (chi-square = 43.35, $P < 0.001$).

While there some species have returned to some sites, their densities remain low and on the whole show little evidence of recovery. Densities reported at the four sites are lower than those reported for the whole of Egypt in 2002 (Table 1).

For the additional six sites visually surveyed there are again mixed observations. These indicate that *H. atra* has returned to Fanadier and *H. nobilis* to Small Magawish. *A. mauritiana* was also found to have returned to Ben-Elgebal and Big Giftun, but appears to have disappeared from Small Giftun (Table 2).

Discussion

Lawrence et al. (2004) found that Egypt's sea cucumber fishery had followed a similar pattern found elsewhere: a boom in the fishery followed by a collapse of most stocks. There were no sites in

Egypt that had not been fished. However, the comparison between sites with some protection, such as El-Gemsha Bay, with those heavily exploited showed a significant difference, with the most valuable species completely absent at the heavily fished sites (Lawrence et al. 2004).

Based on the current survey, a ban on the fishery in late 2003 appears to have had a positive but limited impact on the fishery. However, a comparison of species densities in the current study with densities in 2002 (and with some published in the Indo-Pacific region) indicate that while some species have returned to some sites, their populations have not recovered to previously reported levels or to the highest levels reported elsewhere (Shelley 1981; Preston 1993; Lawrence et al. 2004). However, population densities still remain above those reported in the Torres Strait, Great Barrier Reef or Warrior Reef (Long et al. 1996; Skewes et al. 2000; Uthicke and Benzie 2001; Kinch 2002).

Based on the evidence from this study, it appears that there may have been a slight recovery of some commercial stocks in some sites, but there has been no real overall recovery of sea cucumber stocks.

Acknowledgements

This study forms part of a large follow-up project that has been supported by the Darwin Initiative (Project Reference: EIDPO8/10-027). We wish to thank Mr Mohammed Yosri who helped with the survey work and the EEAA for logistical support.

Table 1. Density of commercial sea cucumbers per hectare in Egypt.

Species	Northern Red Sea (Gulf of Aqaba)		Egyptian Red Sea coast	
	Previous study	Current study	Previous study	Current study
Holothuria scabra	0.0	0.0	158.0	2.0
Stichopus herrmanni	28.0	0.0	46.0	5.0
Stichopus horrens	4.0	0.0	19.6	4.0
Actinopyga mauritiana	70.0	14.0	204.0	15.0
Holothuria atra	950.0	285.2	1002.4	394.3

Table 2. Occurrence of commercial holothurian species at six sites on the islands off the Hurghada coast in 2002 and 2007.

Sites	*H. atra*		*A. mauritiana*		*P. graeffei*		*H. nobilis*	
	2002	2007	2002	2007	2002	2007	2002	2007
Ben-Elgebal	P	P	A	P	A	A	A	A
Small Magawish	P	P	P	A	P	P	A	P
Big Magawish	P	P	A	P	A	A	A	A
Big Giftun	P	P	P	P	A	A	A	A
El-Ghona	P	P	P	P	A	A	A	A
Fanadier	A	P	P	P	A	A	A	A

P = present, A = absent

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Seychelles' sea cucumber fishery: Data on processed products and other parameters

Riaz Aumeeruddy[1] and Chantal Conand[2]

Abstract

The sea cucumber fishery in the Seychelles has recently experienced rapid development. In order to implement a management plan for this fishery, more data are needed on the fished products, their processing and general socioeconomics. In this article, we present new data on the sea cucumber products obtained from the five main holothurian species fished. These data will also be useful for a description of species characteristics and for the market grades. The recent data on catch, effort, and catch per unit of effort are also presented and discussed.

Introduction

Because the sea cucumber fishery has recently expanded in the Indian Ocean, a regional Marine Science for Management (MASMA) Project, funded by the Western Indian Ocean Marine Science Association (WIOMSA), was set up in collaboration with five countries (Kenya, La Reunion, Madagascar, Seychelles and Tanzania). The main objectives for the biology and socioeconomic portion of the project were presented by Conand et al. (2006)

Reports of beche-de-mer exports from the Seychelles date back to the late 1800s (Aumeeruddy, in Conand and Muthiga in press). However, the quantities fished were fairly low and it wasn't until the late 1990s that the fishery experienced rapid development. The main reasons for this increase were the high demand for beche-de-mer on the international market, and higher prices offered for the product (Aumeeruddy and Payet 2004). The fishery has evolved from one in which fishers collect sea cucumbers while walking, to a more sophisticated fishery in which divers use scuba gear to do most of the harvesting. This is because the most valued commercial sea cucumber stocks have been overfished in the shallow coastal areas, and fishermen must now harvest them from deeper fishing grounds (i.e. to depths of 40 m). Many fishers have only entered the fishery in the last eight years. The Seychelles Fishing Authority (SFA) implemented some management measures in 1999 in response to local depletion of some species. These measures included a licensing system for fishing and processing sea cucumbers, a quota on the number of fishing licenses allocated each year, and a limit of four divers for each fishing license. Before the recent interest in the fishery, very little was known about holothurians from the Seychelles.

In May 2007, as part of the MASMA project, a visit was organised by SFA in Mahé (Seychelles) for two of the project's scientists. The main goals were to collect data on the processed products and to analyse the socioeconomic organisation of this fishery through interviews with key stakeholders. The socioeconomic information will be used at a later stage to develop a regional approach to the management of the holothurian fishery in the western Indian Ocean. The socioeconomic aspects of the Seychelles fishery will also be presented in another contribution to this bulletin. Other data on the fishery are presented here.

Material and methods

Interviews and measurements of the products were conducted at the main processors' stores in May 2007.

The main species targeted by the fishery were identified. The appearance of the sea cucumbers — first "in salt" (i.e. gutted sea cucumbers preserved in salt) when they are brought back from the sea, then processed and dried — was observed and photos were taken (Fig. 1).

The length and weight distribution of the processed sea cucumbers were measured for a large sample. Correlations between length and dried weight were calculated for the main species.

Other data collected by SFA were also compiled and analysed. Fishing effort is expressed as the number of dives, catch is expressed as the number of speci-

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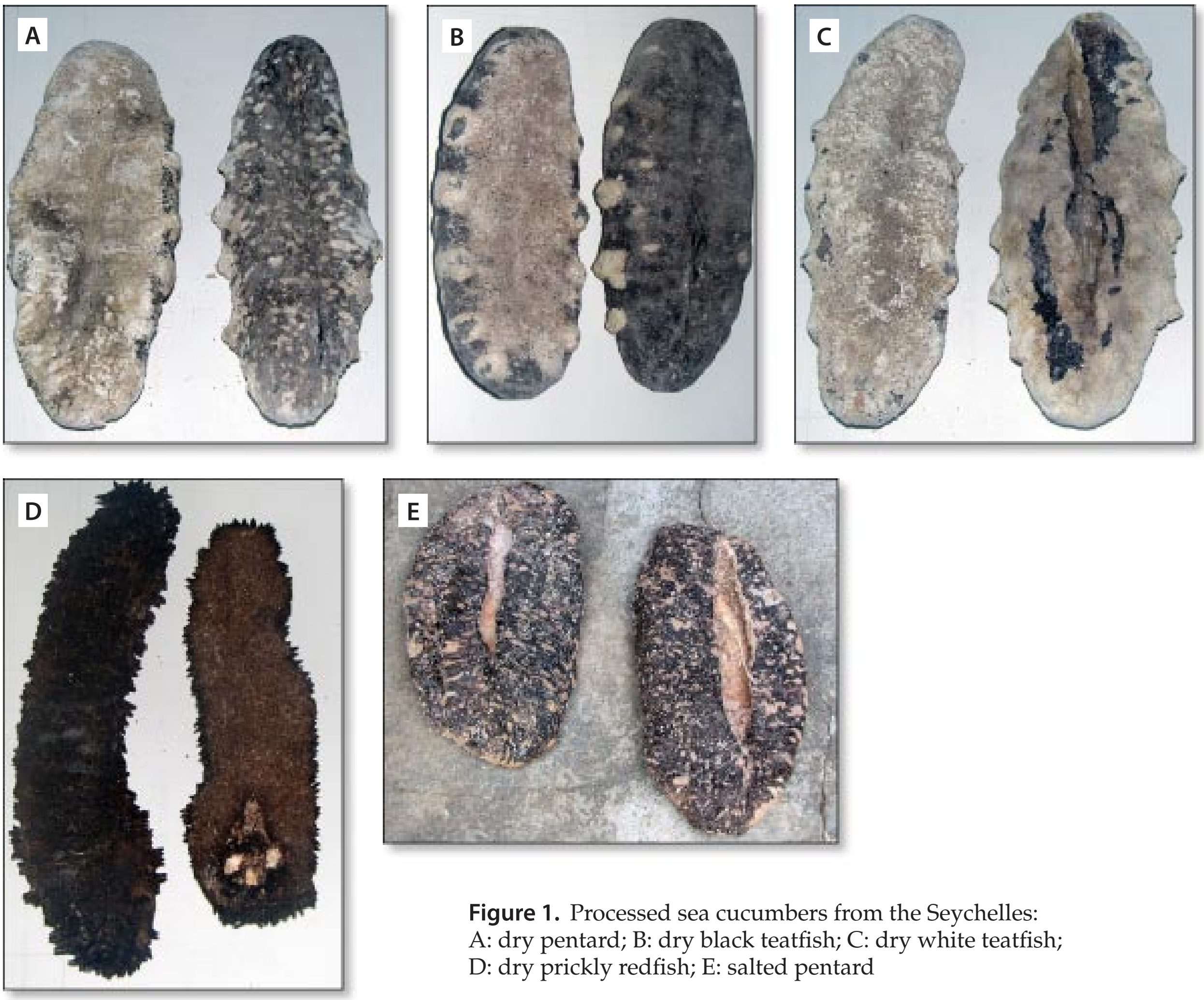

Figure 1. Processed sea cucumbers from the Seychelles:
A: dry pentard; B: dry black teatfish; C: dry white teatfish;
D: dry prickly redfish; E: salted pentard

mens for each species, and catch per unit effort (CPUE) is defined as the number of sea cucumbers of each species collected per dive.

Results

Parameters of the main species

Black teatfish *H. nobilis*, white teatfish *H. fuscogilva*, prickly redfish *T. ananas*, and the yet undescribed teatfish locally called "pentard", were the most common species (Fig. 1). Blackfish, *Actinopyga miliaris*, was also relatively abundant. More information on the species collected is given in Aumeeruddy (in press), Aumeerruddy et al. (2005) and Aumeeruddy and Payet (2004).

The mean size and weight of the products, as well as the reduction in size and weight during processing, are shown in Table 1.

The "pentard" is the most targeted species and dominates the purchases of the two main processors. The sizes are rather similar in the two stores and correspond to large dried specimens (166 g mean weight, or approximately 6 pieces per kg). This is grade A, the most expensive on the market. The products "in salt" are larger than the processed ones; the loss in weight and the loss in length from salted to dried products are calculated (Table 1C). The dried product is only 43% in length and 29% in weight for the prickly redfish; 53% and 42%, respectively for the black teatfish; and around 63% and 33%, respectively for the white teatfish and pentard.

In Figure 2, the size and weight distribution frequencies (and statistical parameters) are presented for the different species. They will be useful for monitoring the fishery as they present the minimum and maximum values and the calculated mode. If a decrease is found in these values in the following years, further management measures will be necessary.

Finally, the length–weight relationships were calculated from these samples (Fig. 3). The regression

Table 1. Mean parameters of sea cucumbers from the Seychelles fishery, May 2007.

species	market name	mean length (cm)	mean weight (g)
A. Dried products			
Holothuria "pentard" (1)	flower teatfish	17.4	167.7
Holothuria "pentard" (2)	"	16.8	165.3
Holothuria fuscogilva	white teatfish	18.9	219.5
Holothuria nobilis	black teatfish	14.3	163.1
Thelenota ananas	prickly redfish	17.8	132.0
Actinopyga miliaris	blackfish	12.2	51.6
B. "In salt" products			
species	**market name**	**mean length (cm)**	**mean weight (g)**
Holothuria "pentard" (1)	flower teatfish	27.5	655.2
Holothuria "pentard" (2)	"	28.2	482.3
Holothuria fuscogilva	white teatfish	29.5	610.0
Holothuria nobilis	black teatfish	27.0	390.0
Thelenota ananas	prickly redfish	41.0	458.0
C. Reduction in length and weight			
species	**market name**	**% length dried/salt**	**% weight dried/salt**
Holothuria "pentard" (1)	flower teatfish	63	26
Holothuria "pentard" (2)	"	60	34
Holothuria fuscogilva	white teatfish	64	36
Holothuria nobilis	black teatfish	53	42
Thelenota ananas	prickly redfish	43	29

(1): Processor 1; (2): Processor 2.

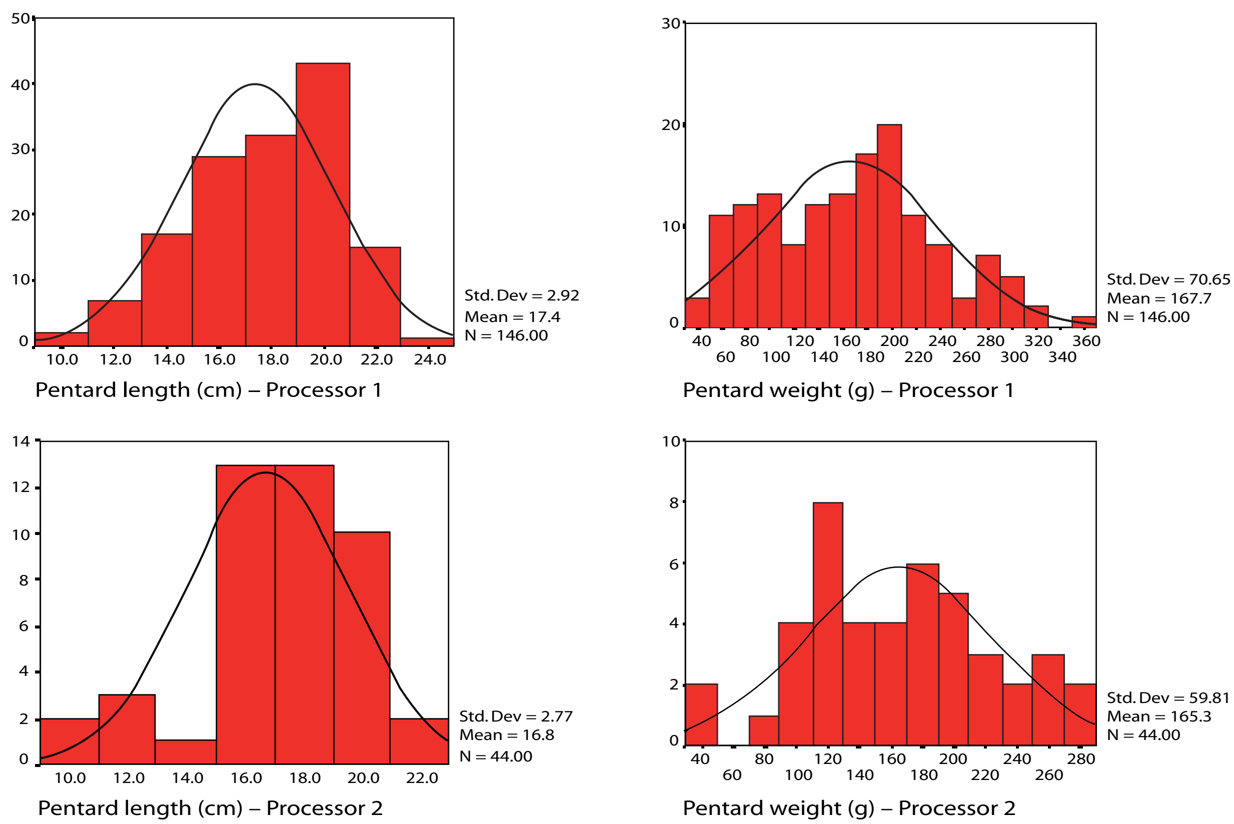

Figure 2. Length and weight distribution frequencies of dried beche-de-mer for the main species fished in Seychelles.

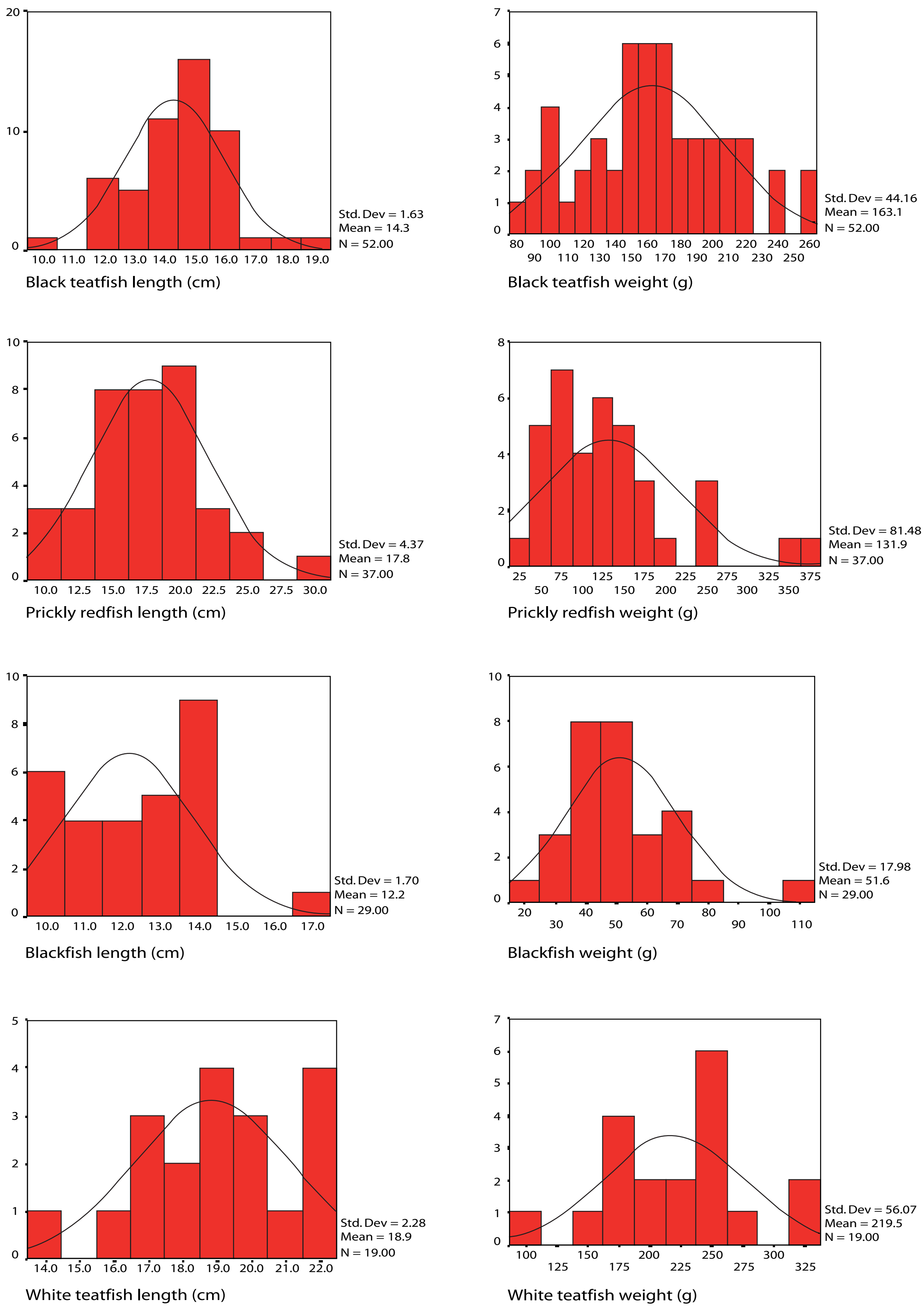

Figure 2 (continued). Length and weight distribution frequencies of dried beche-de-mer for the main species fished in Seychelles.

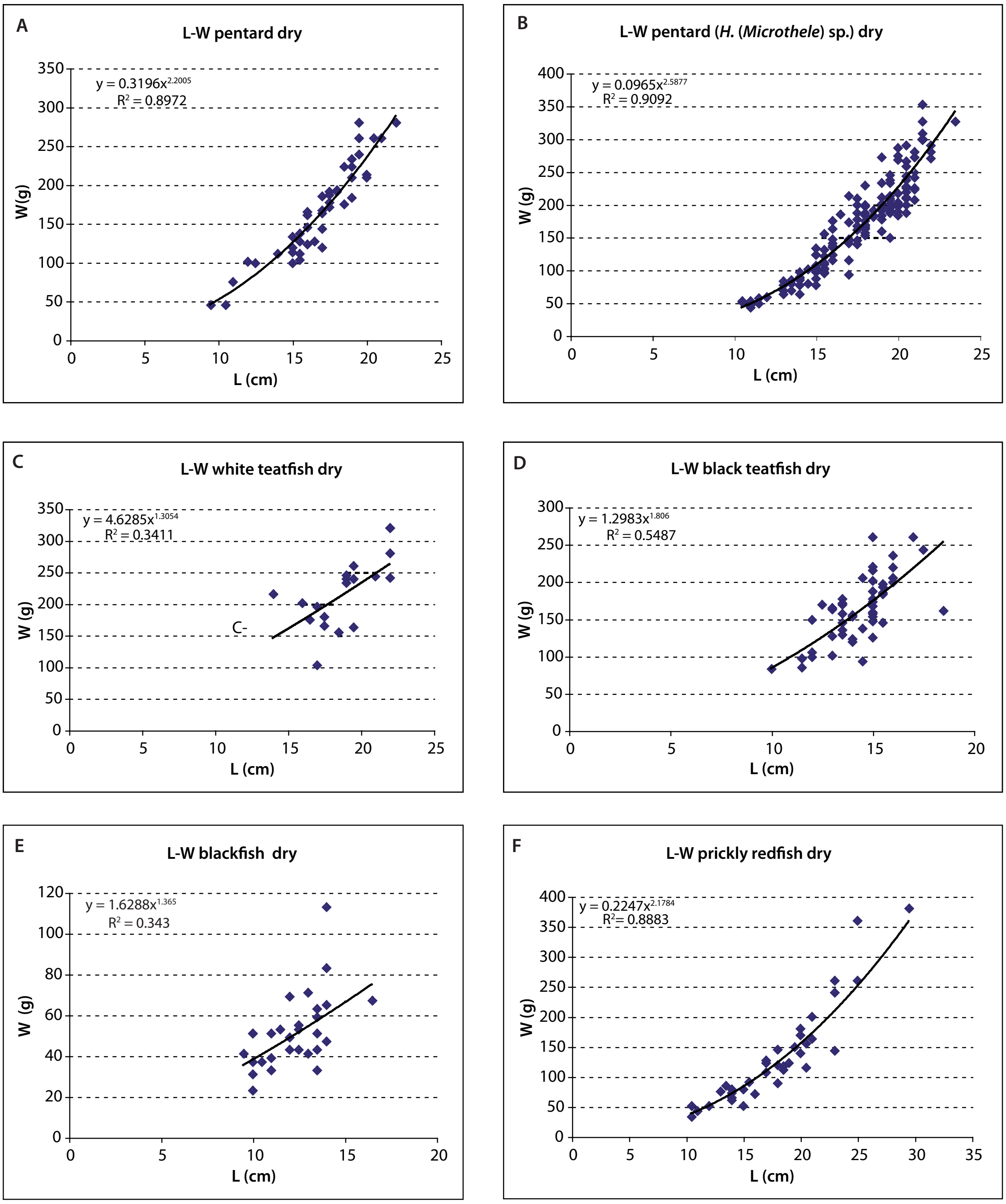

Figure 3. Length-weight relationships and correlations of dried beche-de-mer for the main species fished in Seychelles.

coefficients are highly significant for the pentard, *H. nobilis* and *T. ananas*. Other data are still necessary for the blackfish as the sample measured was small.

Recent data on the fishery

Total effort for the years 2001–2006 is described as the number of dives, and the catch for each species is described as the number of specimens (Table 2). Effort has increased considerably during this period. The pentard is largely dominant but the category "other species" is also important.

Monthly variations in effort are presented for the years 2004–2006 (Fig. 4). The fishery has been increasing during these years, but the fishing season is the same, taking place from October to May, in relation with climatic conditions.

CPUE was calculated from the data presented in Table 2. The results (Table 3) indicate a regular decrease for all the species, with the exception of the pentard. This result is very important for the fishery and management measures must be followed, as overfishing appears for most species.

Discussion and conclusion

Sea cucumber species were present in two forms at the processors' stores in May 2007: "in salt" as they were bought from the fishers, and dried after processing. The processing was done very carefully, following the standard methods (SPC 1984).

The size and weight frequency distribution of the products give information on the mean values of the dried products for each species and therefore their grade on the international market. This parameter is also important for future monitoring in order to evaluate stock status and socioeconomic aspects of the fishery. The loss of length and weight during processing is calculated here from the "in salt" product; this was previously obtained from the fresh weight (see Conand 1979 for New Caledonia) as the animals were not placed in salt because the fishers were going out for one day only and brought the animals back alive.

Statistics on effort and catches are very important. It is recommended that SFA inspectors collecting these data receive training in the taxonomy of the commercial species. It is necessary, with the increase of the catch in the "other species" category, to detect shifts in the fishery, which can result in overexploitation. Some important species that are today classified as "other species" should be identified to the species level to identify trends in their exploitation.

In conclusion, there is a need to control the effort in the fishery, and to monitor it closely. A number of recommendations have been proposed to maintain a sustainable fishery, and are as follows (from Aumeeruddy in press):

1) Control fishing effort so that catches do not exceed recommended total allowable catches (TACs). Management measures should be designed to control effort on the higher value species and to spread effort to lower value species.
2) Control fishing effort in areas close to the main islands of the Mahé Plateau for high value species to alleviate local depletion of these species.
3) Continue to protect all sea cucumber populations in the designated marine parks.
4) Formulate, enforce and educate about minimum size limits for all species in the catch. Minimum size limits should be designed in order to protect individuals until they have spawned once.
5) Monitor the catch and effort of the fishery through suitable logbooks and processor returns. Information should be gathered for all species in the catch.
6) Carry out periodic monitoring surveys to assess the performance of the current management strategies and modify if required.

Table 2. Data on effort (total no. of dives) and catch (no. of specimens) for the Seychelles fishery (2001–2006).

Year	No of dives	Black teatfish	Sandfish	White teatfish	Prickly redfish	Pentard	Other species	Total catches
2001	576	4117	114	16758	2802	2784	3427	30002
2002	1349	6411	708	40555	6302	9875	40173	104024
2003	2559	8243	33	25510	15579	47810	69482	166657
2004	5154	9388	622	41141	12249	59331	52181	174912
2005	7609	11600	100	45928	17187	83798	98032	256645
2006	9340	9821	1753	36817	13375	151459	94127	307352

Table 3. CPUE (no. ind dive^{-1}) for the main holothurians fished in Seychelles (2001–2006).

Year	Black teatfish	Sandfish	White teatfish	Prickly redfish	Pentard	Other species
2001	7.15	0.20	29.09	4.86	4.83	5.95
2002	4.75	0.52	30.06	4.67	7.32	29.78
2003	3.22	0.01	9.97	6.09	18.68	27.15
2004	1.82	0.12	7.98	2.38	11.51	10.12
2005	1.52	0.01	6.04	2.26	11.01	12.88
2006	1.05	0.19	3.94	1.43	16.22	10.08

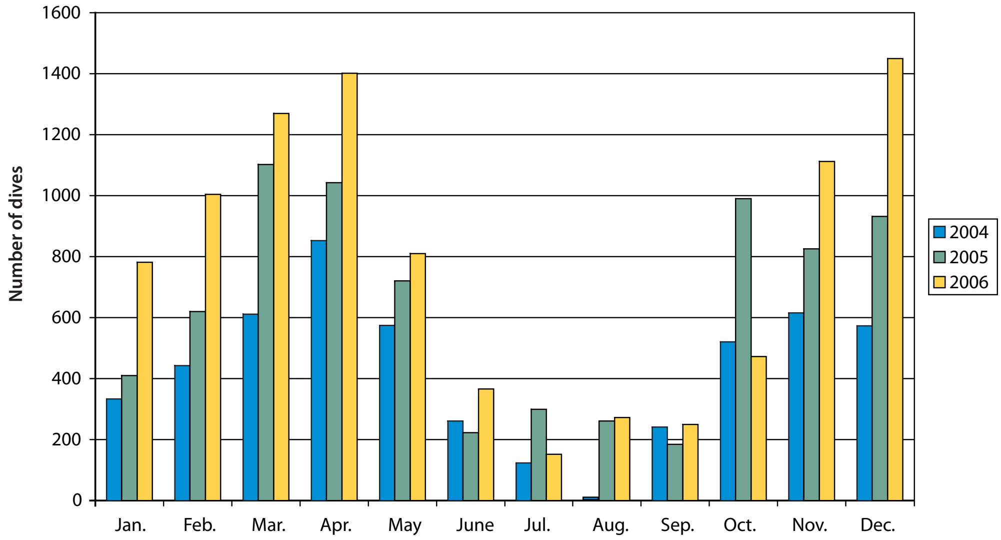

Figure 4. Monthly variations of effort (no. of dives) in the Seychelles sea cucumber fishery.

A management plan has been proposed based on the results of the resource assessment (Aumeeruddy et al. 2005). Following meetings with stakeholders, the plan was finalised in August 2005, and is based on a mix of input controls (limited number of fishing licenses) and output controls (TAC for each commercial species) (Payet 2005). It was agreed to continue with a limit of 25 fishing licences, which was implemented as a precautionary measure in 2001. TAC was calculated based on maximum sustainable yield (MSY) for each species (Aumeeruddy et al. 2005). The total TAC for all species has been calculated at 1707 t landed weight (gutted), from which high value species represent 425 t landed weight, medium value species (e.g. blackfish) made up 121 t (7.1%), and low value species (e.g. lollyfish) made up 1161 t (68.0%).

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Application of the Two-Term Local Quadrat Variance Analysis in the assessment of marine invertebrate populations: Preliminary findings on the sea cucumber *Actinopyga echinites*

Grant Leeworthy

Abstract

The Two-Term Local Quadrat Variance analysis (Hill 1973) has an application for quantifying spatial patterns in marine invertebrate populations. This method provides a crucial step in the process of accurately designing population surveys and monitoring programmes for fisheries that exhibit small- to medium-scale patchiness. Data from the spatial pattern analysis technique can be used to base stratification decisions upon rather than relying upon "intuition" as suggested by Andrews and Mapstone (1987). Consideration of spatial pattern in survey design can ensure that monitoring programmes are designed in a manner that can measure distribution and abundance at a scale relevant to the population. The method is readily applied in the marine setting using conventional underwater visual census (UVC) techniques. The method was used to assess populations of the deepwater redfish (*Actinopyga echinites*), a tropical holothurian that is abundant in the Indo-Pacific region on eroded limestone platforms at 0.5–7 m depth. The species was chosen for this study due to the lack of prior fishing pressure on the population.

Introduction

Designing a sampling programme that adequately describes a population of marine organisms is a challenging task. Population surveys are commissioned for several reasons, including environmental monitoring and fisheries assessment. The process for designing a stock survey requires: 1) the consideration of the resources available for the completion of the survey, 2) the biology and potential distribution of the target organism, 3) the desired level of precision and accuracy of the estimates, and 4) the type, number and placement of sampling units to balance these aims. Often the available resources for completing a survey are restrictive and a balance needs to be struck between the conflicting goals of precision and the minimization of costs (Pitcher et al. 1992). One of the shortcomings of traditional stock assessment methods has been the failure to adequately address the localised spatial pattern of the population of interest. A population may exhibit a random, uniform or clumped distribution pattern over various scales of measurement and it is important that sampling designs take this into account. A recent shift to the use of more systematic (as opposed to random or haphazard) sampling designs has seen greater focus placed upon the usefulness of a sampling programme to map the distribution of a species (e.g. Cochran 1977; Hender et al. 2001; Skewes et al. 2000; Mayfield et al. 2004; Chick et al. 2006; McGarvey 2006; Leeworthy 2007a,b). This spatial information provides a powerful tool for monitoring programmes to assess and manage the impacts of fishing pressure or other environmental disturbances.

Several methods of spatial pattern analysis for use within the marine environment have been tested. The "point-nearest neighbour" method (Byth and Ripley 1980; Byth 1982; Officer et al. 2001) has recently been shown to be impractical to apply within the marine environment (McGarvey et al. 2005; McGarvey 2006). Quadrat-Variance methods have been shown to successfully describe spatial pattern in terrestrial ecological studies. These methods are based upon examining the changes in the mean and variance of the number of individuals per sampling unit over a range of different sample sizes (Ludwig and Reynolds 1998). Data are gained from belt transects of contiguous quadrats (i.e. a joined or continuous series of quadrats) placed in a linier manner across the population of interest. The variance of the number of individuals is calculated at different "block sizes". The block sizes are obtained by combining progressively the *N* quadrats (therefore increasing the theoretical sample unit size) in a prescribed manner (Ludwig and Reynolds 1998). In populations displaying a patchy or clumped distribution (such as many holothurian species), the variance peak (maximum variance) can be interpreted as being equivalent to the radius of the patch.

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The Two-Term Local Quadrat Variance analysis (TTLQV) is a modification of the basic blocked quadrat variance (BQV) methods for spatial pattern analysis that are limited to powers of 2 (Ludwig and Reynolds 1988). The TTLQV uses variance data in a similar manner to the BQV method although it has a more refined "blocking scheme" in its calculation to overcome the BQV's limitation. This paper reports on the successful application of the TTLQV for the assessment of spatial patterns in marine invertebrate populations, using the sea cucumber *Actinopyga echinites*, and discusses the advantages of this relatively simple method.

Methods

The study site was a 3–5 m deep eroded reef platform in the Montebello Islands in Western Australia. The population of interest was the holothurian *Actinopyga echinites* (Fig. 1). A hip-chain device and sampling station were used to complete the transects of contiguous quadrats in a similar fashion as described by Leeworthy and Skewes (see article on p. 5). The main difference was that a count (number of *A. echinites*) was made for each 1 m traveled and recorded on the data sheet. The sampling station was only 1.25 m wide due to the cryptic nature of the species in weed beds. One quadrat represented an area equal to 1 m x 1.25 m. Three replicate transects of 200 contiguous quadrats each were completed in an area where a high abundance of *A. echinites* had been previously located or where the population was presumed to extend to.

The TTLQV analysis was used as per Hill (1973) and Ludwig and Reynolds (1988). The TTLQV equation for block size 1, 2 and 3 is shown below.

Block size 1

$$VAR(X)1 = [1/(N-1)]\{[1/2\,(x_1 - x_2)^2] + [1/2\,(x_2 - x_3)^2] + \dots + [1/2\,(x_{N-1} - x_N)^2]\} \quad (1)$$

Block size 2

$$VAR(X)2 = [1/(N-3)]\{[1/4\,(x_1 + x_2 - x_3 - x_4)^2] + [1/4\,(x_2 + x_3 - x_4 - x_5)^2] + \dots + [1/4\,(x_{N-3} + x_{N-2} - x_{N-1} - x_N)^2]\} \quad (2)$$

Block size 3

$$VAR(X)3 = [1/(N-5)]\{[1/6\,(x_1 + x_2 + x_3 - x_4 - x_5 - x_6)^2] + [1/6\,(x_2 + x_3 + x_4 - x_5 - x_6 - x_7)^2] + \dots + [1/6\,(x_{N-5} + x_{N-4} + x_{N-3} - x_{N-2} - x_{N-1} - x_N)^2]\} \quad (3)$$

Where X is the variance at the given block size, N is the total number of quadrats in a transect, x_1 is the number of individuals within the first quadrat in the transect, x_2 is the second and x_N is the last quadrat. Computations analogous to Eq. 3 are made at successively larger block sizes (Ludwig and Reynolds 1988). Calculations for the TTLQV were conducted using Microsoft Excel, although the use of Microsoft Visual Basic is recommended for longer transects of contiguous quadrats.

Figure 1. *Actinopyga echinites.*

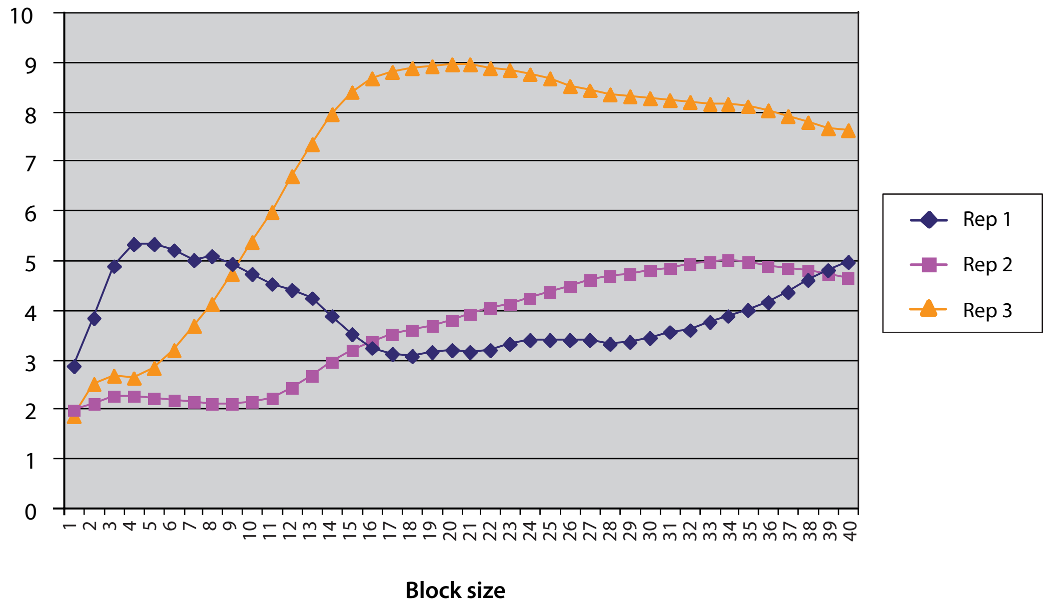

Figure 2. Two-Term Local Quadrat Variance for *A. echinites* in the Montebello Islands.

Results

The results of the TTLQV analysis for *A. echinites* in the Montebello Islands, Western Australia are shown below in Figure 2.

Table 1. Calculation of patch diameter using peak variance results.

Peak variance	
Replicate 1	42
Replicate 2	34
Replicate 3	21
Mean variance	32
Mean patch diameter (m)	64

The data presented in Table 1 suggest that sample units for an abundance survey of this population would need to be at least 84 m in length (two times the radius of the largest patch). It should be noted that while the mean patch diameter is informative to the researcher as defining the spatial pattern of the population, when using this data to design a survey of distribution and abundance, the maximum patch size should be considered to overcome auto-correlation of samples.

Discussion

As the distribution and abundance of an organism in the marine environment is often patchy or clumped, it is important that the spatial scale of this patchiness is taken into account when designing a sampling programme. The size of a sampling unit has a marked effect on the precision of sample estimates (King 1995). For species displaying a patchy or aggregated distribution, it has been suggested that the size of the sampling unit should be larger than the distance between the aggregations, so that each sampling unit includes at least part of an aggregation (King 1995). The TTLQV analysis can be employed to quantify the size of aggregations so that decisions regarding sample size and position can be based on a quantitative process rather than relying upon "intuition" as suggested by Andrews and Mapstone (1987). For this reason, the TTLQV analysis is an extremely useful tool in making decisions regarding appropriate sampling design.

It is important to note that several scales of patchiness are observable in the populations of most marine organisms. One scale is that of the individual organism and its immediate aggregation (e.g. five abalones in a crack). The second scale of patchiness is the larger patch of high abundance (e.g. a large patch of abalone covering 600 m^2). The third is the environmental habitat gradient (e.g. 2 km^2 of reef) and the fourth is the scale of fishing pressure or environmental effect of interest, if it exists. Many larger or smaller scales of patchiness may also exist,

particularly when considering habitat complexity and details such as the specific surface area (m^2/m^3) or reef rugosity. If the suggested four basic scales of patchiness are taken into account when designing the size and placement of samples in the environment, an increased level of certainty can be demonstrated in the outcomes of a survey. The TTLQV analysis has the capability of quantifying these scales of patchiness in a robust manner.

It is suggested that several replicate, contiguous quadrat-transects should be placed in groups spread over the areas where the survey is planned. The decision as to where to place these transects could be based on as little *a priori* information as knowing the location of the population. Further *a priori* knowledge such as depth contours and habitat maps (once tested with the TTLQV analysis) can give enough information to make robust stratification decisions.

The TTLQV analysis gives the peak variance for the location studied. This peak variance corresponds to the radius of the aggregation; therefore the diameter of an aggregation equals two times the radius. If three replicate, contiguous quadrat transects were undertaken in a location, the largest aggregation size should be used to base sampling design decisions on. The range may also be useful for consideration. The length of survey transects could then be set at a distance equal to at least twice the largest aggregation diameter. Placement of transects could be arranged to adequately take into account the broader scales of variance for each area of interest such as habitat gradients and patterns of fishing pressure. It is important to note that precision reduces beyond a block size of N/10 for the TTLQV. For this reason it is recommended that relatively long transects are conducted in order to take into account the potential scales of spatial pattern. Three replicates of TTLQV transects, 500 m in length, have been completed for a similar population on the Great Barrier Reef, although this was the maximum length possible due to the water depth (~18 m) and associated decompression limitations (Leeworthy unpublished data).

Several extensions to the TTLQV analysis have been made (Malatesta et al. 1992; Dale and Blundon 1990; Campbell et al. 1998) and it is probable that these will be incorporated into methods for future benthic invertebrate surveys.

With regard to fisheries management, Walters and Martell (2006) have recently contended that direct surveys of abundance are less useful than estimates of fishing mortality (F). It is this author's view however that without direct consideration of the various spatial scales that a fishery operates on, it is quite possible that an estimate of F will not detect large shifts in biomass. Prince (2005) discusses the need to understand the relevant spatial scales affecting an invertebrate fishery. Use of the TTLQV analysis is a step closer to gaining a full understanding of the dynamics of such fisheries.

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Probiotic yeasts with phytase activity identified from the gastrointestinal tract of sea cucumbers

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Abstract

Yeasts are microorganisms commonly found in the gastrointestinal track of animals, and several yeast strains produce phytase. The present study focused on the isolation of yeast species from sea cucumbers and on the yeasts' ability to produce phytase. Two strains of phytase were isolated and identified: *Yarrowia lipolitica* and *Candida tropicalis*. These strains produced high amounts of extra cellular and cell bound phytases. These could be used as probiotic yeasts by the sea cucumber farming industry.

Introduction

The intestines of animals contain large amounts of microorganisms that have specific functions such as catabolic breakdown of fibres and complex nutrients, as well as the production of vitamins. Raibaud (1992) reported that intestinal microorganisms play a role against pathogenic microbes and that the imbalance of gut microorganisms can lead to the rapid growth of opportunistic pathogens that can be harmful to the host animal. The possibility of using intestinal microbiota as probiotics has been reported by Hirimuthugoda et al. (2006). This study was carried out to better understand intestinal microorganisms in sea cucumbers and to develop probiotic microorganisms for sea cucumber farming.

As a main component of DNA, phosphorous is a vital element. Cereals, legumes, fodder and root crops store phosphorous as phytate and phytin, which can only be digested by ruminants; with other animals, undigested phosphorous is released into the environment. Accumulation of undigested phosphorous in soils and waters is toxic.

Phytases can have a significant role in controlling phosphate pollution due to their capability of catalysing the release of phosphate from both phytate and phytin. Recently, microbial plants and animal-derived phytases have been made available as feed supplements. They have become the most popular and widely used enzymes in animal farming systems. However, scientists have not yet studied marine microbial phytases. Therefore, we made an attempt to isolate microbial species from the gut of sea cucumbers to study their ability to secrete phytase.

Materials and methods

Sampling and yeast isolation

Sea cucumbers from coastal areas of Sri Lanka and China were collected randomly and dissected under aseptic conditions. Guts were separated and homogenized, and 2 mL of homogenized samples were placed into 20 mL of liquid YPD (2% glucose, 2% polypeptone, 1% yeast extract and seawater) culture medium, which was treated with antibiotics and cultured at 28°C for five days. After five days, cell cultures were plated on YPD agar plates and yeast colonies were transferred to slants.

Assay of phytase activity

Yeast strains were inoculated into 250 mL flasks with a 50 mL medium containing 0.5% sodium phytate, 1% ammonium sulfate, vitamins and mineral salts, and grown for five days at 28°C. The supernatants were assayed by measuring the amount of phosphate released (Fiske and Subbarow 1925) using sodium phytase as the substrate (Vohara and Satyanarayana 2001). One unit of phytase is defined as the amount of enzyme that liberates 1 mU inorganic phosphate per minute at ambient temperature. The effect of temperature and pH on phytase activity was studied by incubating the enzyme at pH 4–9 (buffers used were 0.2 M Acetate for 4–6 and 0.2% M $Na_2B_4O_7.10\ H_2O\text{-}HBr_3$ for 7–9) and at temperatures of 37°C, 45°C, 50°C, 55°C, 60°C, 65°C and 70°C.

DNA extraction, PCR and phylogenetic analysis

The total genomic DNA of the yeast strains was isolated and purified by using the method described

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by Sambrook et al. (1989). The 18S rDNA fragment and ITS fragment inserted on the vector were sequenced by Shanghai Sangon Company. The sequences obtained above were aligned by using BLAST analysis (http://www.ncbi.nlm.nih.gov/BLAST). The routine identification of the yeasts was performed by using the method described by Kurtzman and Fell (1998).

Results and discussion

Two yeast strains were isolated and both strains were obtained from the gut of *Holothuria scabra*. Generally, animals have a large number of gut-colonized microorganisms in their gastrointestinal tract. Our results show that the microorganisms were isolated from the gut content and therefore, to our knowledge, these strains cannot be categorized as gut-colonized yeasts. Further research work is necessary on this aspect. Strains were labelled as W2B (from China) and YF12C (from Sri Lanka). Based on the biochemical characteristics and on similar information for the type of strains listed by Kurtzman and Fell (1998), we found that strain W2B and YF12C were similar to *Yarrowia lipolitica* and *Candida tropicalis*. DNA sequences analysis of phylogeny with those in the National Center for Biotechnology Information (NCBI) database further confirmed that the yeast strains obtained in this study were closely related to *Yarrowia lipolitica* (W2B) and *Candida tropicalis* (YF12C). 18S rDNA sequences of yeast strains were deposited in NCBI under the Accession Nos. of DQ 438177 –W2B and DQ 515959- YF12C.

Table 1. Phytase activity of two yeast strains.

Strain	phytase activity (mU min^{-1})	optimum temperature (°C)	optimum pH
W2B	61 $\pm$ 0.011[a]	60	8
YF12C	49 $\pm$ 0.008[a]	55	8
	28 $\pm$ 0.045[b]	65	6

[a] extra cellular phytase
[b] cellbound phytase

It is interesting to mention that phytase-secreting marine yeasts are present in sea cucumber intestines. A few yeast strains that exhibit phytase secretion have been observed (Pandy et al. 2001), but this was the first report of sea cucumber-derived yeast phytases. Strain W2B was able to produce only extra cellular phytase while YF12C was able to produce both extra cellular and cell bound phytases. Vohara and Satyanarayana (2004) studied cell bound phytase from the yeast *Pichia anomala*, which can be used in the animal feed industry to reduce phosphate pollution.

Temperature and pH are the most influential factors on enzyme production in all studies. In this study, high phytase activity was observed at between 55°C and 65°C. For the strain W2B, 60°C was the optimum temperature. For the strain YF12C, the optimum temperature was 55°C for extra cellular and 65°C for cell bound enzyme production. A pH of 8 was the optimum for extra cellular enzyme production for both strains, while pH 6 was the optimum for cell bound enzyme synthesis of YF12C. In general, the optimum pH and temperature are around 4.5–6 and 45–60°C, respectively (Pandy et al. 2001). However, in this study we observed higher pH values, probably because these strains came from the marine environment.

Yarrowia lipolitica has several physiological properties of industrial significance. The species is abundant in the marine environment, and is well known for the production of proteases, lipase and utilization of *n*-paraffin (Kurtzman and Fell 1998). Although much research has been conducted on *Yarrowia lipolitica*, this paper reports on its phytases. This species can be used at the commercial level for marine phytase production. *Candida tropicalis* is a well-known yeast species found all over the world, and is a common pathogenic strain on humans. Therefore, industrial application of this species is limited, although extracted phytase can be used as an industrial product. Present market trends have very clearly indicated that there is a significant demand for phytase as a feed supplement, and various products under different trade names are available. For example, Cenzyme, Natu-phos, and Gist-Brocades are the leading products (Pandy et al. 2001).

The role or impact of yeasts in the gastrointestinal tract of sea cucumbers is not clearly known but obviously the significant phytase synthesis is favourable for digesting phytate phosphorous as well as a probiotic form. In recent decades, sea cucumber farming increased remarkably and phytate-rich feed components are used. Therefore, this phytase synthesing yeast plays a major role in the food digestion of sea cucumbers. Excretion of undigested phosphorous, leads to eutrophication and causes a decrease in water quality at sea cucumber farms. This situation is favourable for pathogenic microorganisms and, therefore, the yeast phytase observed from sea cucumbers has a significant value in the sea cucumber industry, and all phytases found thus far are not from marine sources. The authors of this paper are conducting further research on the application of these two yeast strains in sea cucumber farming and the purification of enzymes in optimized medium.

Acknowledgement

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An observation on the effect of environmental conditions on induced fission of the Mediterranean sand sea cucumber, *Holothuria arenicola* (Semper, 1868) in Egypt

F.A. Abdel Razek[1], S.H. Abdel Rahman[1], M.H. Mona[2], M.M. El-Gamal[2] and R.M. Moussa[1]*

Introduction

Holothuria arenicola is the most important and abundant sea cucumber species in the Mediterranean Sea on the Egyptian coast (Fig. 1A). It was recorded in 1984 for the first time on the Egyptian Mediterranean coast (Shoukr et al. 1984). Its habitat extends from the Indo-Pacific to the tropical Western Atlantic. It reaches a size of about 26 cm. Presently, *H. arenicola* is overexploited in Egyptian waters due to the increasing demand from Asian markets. The loss of sea cucumber stocks is likely to have a significant negative impact on the ecosystem and the adjacent marine environment as a whole. Therefore, there is an urgent need for intensive studies of the biology, culture and fishery management of *Holothuria arenicola*.

Some holothurians are known for their ability to reproduce asexually by fission. Most holothurian species with asexual reproduction follow the twisting and stretching mode (Uthicke 2001). The first trial to induce asexual reproduction in *H. arenicola* was done by Kilada et al. (2000), who investigated the induction of asexual reproduction by using rubber bands. The present work aims to describe the stages of asexual reproduction by fission and the effect of environmental factors on dividing and survival rates.

Method

Asexual reproduction of *H. arenicola* was induced by fitting rubber bands just in front (the upper 45%) of the middle portion of the body (Fig. 1B). Specimens were kept in a tank with a thin layer of fine sand on the bottom. Water salinity was 36 ppt. The tank's water was changed daily, and the number of divided, undivided and dead animals were reported daily.

Discussion and conclusion

Observations showed that the body was more constricted at the constriction point. The posterior part was swollen and extended. The posterior and anterior parts rotated in opposite directions resulting in more constriction until both parts stretched (Fig. 1C) and finally split, although they were still connected to each other via the gut. After one day, the anterior and posterior parts were completely separated (Figs. 1D and 1E). The survival rate of the posterior part was higher than that of the anterior part. The entire process of fission lasted from one to five days.

Because of electrical problems that affected the water aeration, low survival rates were obtained.

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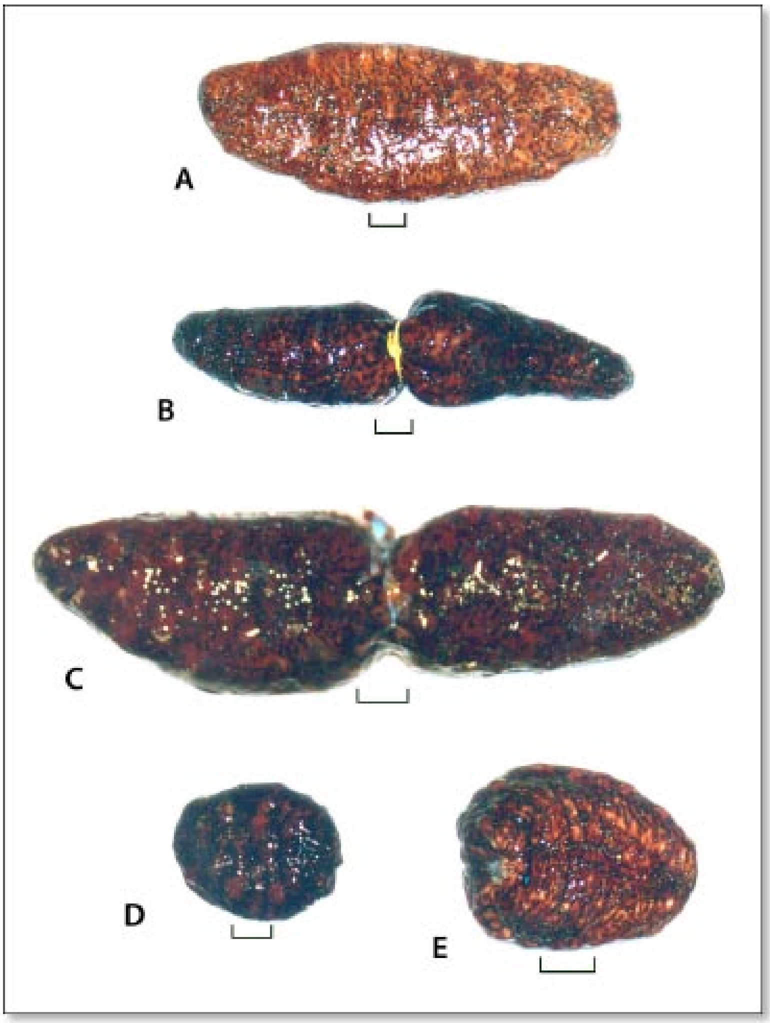

Figure 1. *Holothuria arenicola* induced fission.
A. Live animal before the rubber band is fitted.
B. the rubber band in place;
C. the anterior and posterior parts have stretched before splitting;
D. the anterior part after fission; and
E. the posterior part after fission.
Scale bars are all 1 cm.

Nevertheless, it was noted that individuals that eviscerated at the constriction point had a higher mortality rate than those individuals that kept their viscera. Additionally, temperature showed a considerable effect on the fission process. The dividing rate was greater at high temperatures (30°C) than at low temperatures (25°C). On the contrary, the survival rate of divided parts increased as water temperature decreased.

The wound-healing period lasted longer at high temperatures than at low temperatures. We concluded that the dividing rate increased with an increasing water temperature, while the survival rate of divided parts and the wound-healing period increased when the temperature decreased.

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Spatial distribution and temporal shifts in the biology of the commercial sea cucumber *Holothuria whitmaei* [Echinodermata: Holothuroidea], Ningaloo Reef, Western Australia

Glenn R. Shiell[1]

Source: Abstract from PhD thesis (PhD awarded in September 2006; supervisor: Dr Brenton Knott).

Three components of the biology of the aspidochirote sea cucumber *Holothuria whitmaei* were investigated at Coral Bay, Ningaloo Reef, in Western Australia: 1) spatial distribution, 2) temporal changes in behaviour, and 3) reproduction biology. The spatial distribution of specimens was typical of that reported in the literature. Individuals maintained distinct preferences for outer reef habitats, particularly the outer reef flat and reef slope, at average densities of 19.3–27.1 ind ha^{-1}. The distribution of specimens within these habitats was heterogeneous, with up to 40% of the population being significantly aggregated, particularly at the leading edge of the reef flat perpendicular to the prevailing current. Densities within these aggregations typically exceeded 100 ind ha^{-1}. Two biological advantages of species aggregations were hypothesised: 1) species aggregations enhance the probability of achieving fertilisation, a process that may be impeded under typical densities; and 2) large deposits of detrital matter, an important food source for holothurians, may accumulate within these zones.

Temporal changes in the behaviour of *H. whitmaei* were inferred to be important with respect to feeding and reproduction. Activity of *H. whitmaei* was low in the morning (average max. 3.7 cm h^{-1}) but increased significantly through the afternoon (average max. 31.6 cm h^{-1}). During periods of enhanced activity, between 16.7% and 47.7% of specimens were observed on open sand, at a distance of at least one body length from the nearest coral. Contrasting results were obtained during periods of relative inactivity, when up to 23.3% of individuals were positioned beneath shelter (and thus hidden from view). Seasonal changes in activity were also apparent, with late afternoon rates of activity being significantly higher in April (31.6 cm h^{-1}) than in January and August (17.3 and 15.71 cm h^{-1}, respectively).

Regression analysis investigating the effects of water temperature, light intensity and sediment egestion on rates of activity, found that the effect of these variables explained only a portion of the variation in activity (in the range 9–56%). The April increase in activity is hypothesised to be a function of reproductive activity; specifically, the strong correlation between gonad somatic index and late afternoon rates of activity (r = 0.9) reflects seasonal aggregation prior to spawning. Although energetically expensive, it is suggested that such behaviour may increase the frequency of gamete fertilisation, a process that may be impeded under typical population densities, and in habitats characterised by rapid (and unidirectional) water movement.

Like most tropical aspidochirote holothurians, reproduction in *H. whitmaei* is achieved *via* broadcast spawning; however, in contrast to most aspidochirotes, western Pacific and eastern Indian Ocean populations of *H. whitmaei* spawn over an extended period during the cooler months (April–October); a pattern congruent with that observed in New Caledonia. Gonad maturation in Ningaloo Reef (eastern Indian Ocean) specimens conformed to the Tubule Recruitment Model (TRM), a developmental process whereby distinct tubule cohorts of varying gametogenic status are recruited progressively to the gonad basis. A feature of the reproductive biology of this species was also the potential for asynchronous maturation among individuals; that is, although the majority of specimens sampled at any one time maintained roughly similar stages of gonadal development, smaller numbers were sampled containing gonads at odd stages of development. Such findings may result from sampling isolated individuals that were located too far from conspecifics to receive pheromone signals, cues known to entrain synchronous gonad development in some holothurians.

The bioturbation contribution of *H. whitmaei*, although highly variable on a temporal scale, was found to be low in comparison with more abun-

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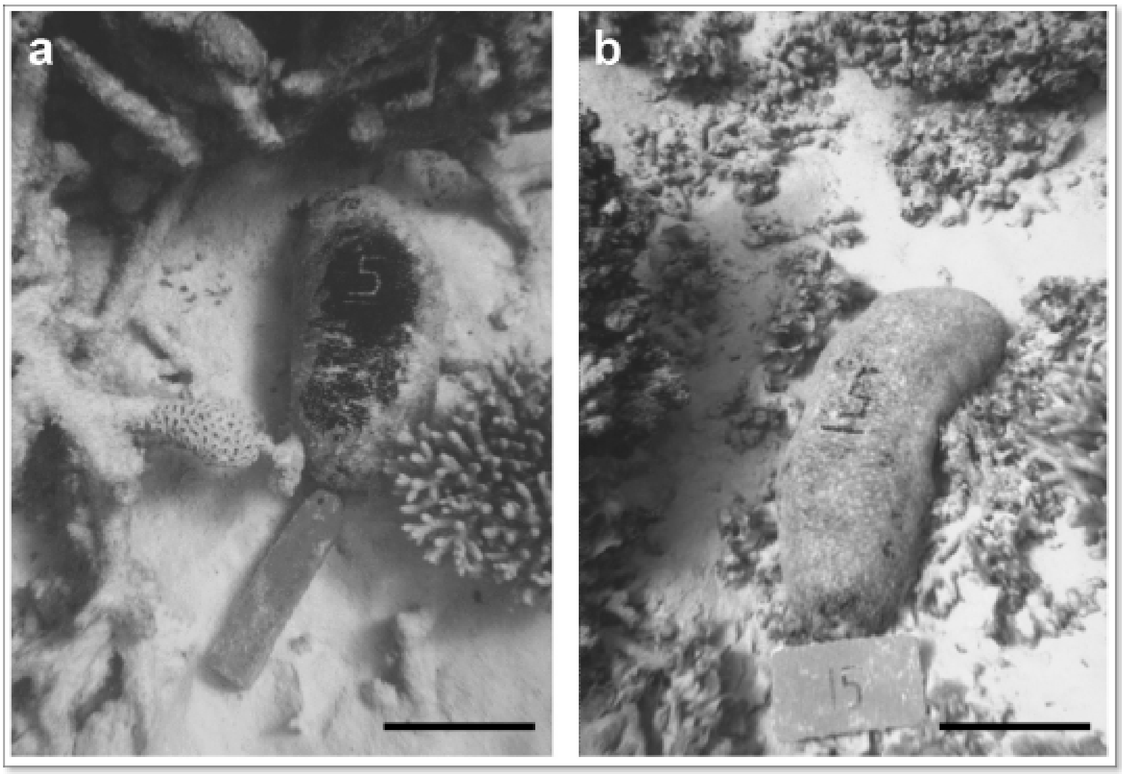
dant coral reef dwelling holothurians such as *Holothuria atra* and *Stichopus chloronotus*. Nevertheless, *H. whitmaei* makes contact with high percentages of sediments simply by crawling, and may therefore contribute to the productivity of coral reefs by transferring dissolved inorganic nutrients directly to the benthos. The maintenance by *H. whitmaei* of highly specific patterns of distribution may have significance for trophic level cascades in the outer reef zone, particularly where this species is present in higher densities (>100 ind ha^{-1}).

The findings of this study, apart from highlighting the spatial and temporal biological attributes that may have facilitated feeding and reproductive success (particularly in outer reef environments), also emphasised the importance of biological knowledge to the management of sea cucumber fisheries. This study highlighted the need for further research to ascertain both the importance of species aggregations to population recruitment, and of the actual densities required to achieve high rates of gamete fertilisation. Such knowledge may help ultimately to identify suitable habitats for inclusion in marine protected areas (MPAs).



Photos (a) and (b) showing the same *Holothuria whitmaei* specimen marked for identification during the behavioural component of the study. Numbers were scratched into the dorsal tegument of each specimen to a depth of approximately 1–2 mm, such that the underlying white flesh (photo a) was clearly visible beneath the contrasting dark skin. The marks healed quickly to form a scar that was then visible for a period of up to three weeks (Photo b). Scale bars represent 18 cm and 15 cm, in Photos (a) and (b), respectively.

Abstracts & new publications...

Sustainability assessment of the Torres Strait sea cucumber fishery

Timothy Skewes, Sascha Taylor, Darren Dennis, Michael Haywood, Anthea Donovan

Source: CSIRO Marine and Atmospheric Research Report, 2006.
[http://www.cmar.csiro.au/e-print/open/skewestd_2007.pdf]

The (modern) Torres Strait beche-de-mer fishery began in about 1990. Sandfish (*Holothuria scabra*) on Warrior Reef provided the bulk of the early catches in the fishery, until a stock survey in 1998 found that the population was severely depleted and the sandfish fishery was closed. Subsequent surveys in January 2000 and October 2002 found a small recovery in the population, especially of the breeding cohort, but it was still considered heavily depleted.

After 1998, the fishery mostly targeted black teatfish (*H. whitmaei*), white teatfish (*H. fuscogilva*) and surf redfish (*Acyinopyga mauritiana*) in east Torres Strait. However, a survey in March 2002 found that black teatfish and surf redfish were also overexploited, and a prohibition on the harvest of these species was introduced in January 2003. Other targeted species, such as white teatfish and prickly redfish, were not considered overexploited at the time, but it was recommended that their catches be restricted and the populations be closely monitored. Several other species, mostly of low value but often having a large standing stock, were considered to be at near virgin biomass levels.

This current research project was based on two population surveys, one of sandfish on Warrior Reef in January 2004 and one of all other species in east Torres Strait in January 2005. These surveys were designed to provide information on the stock status of fished species and recovery of depleted species. For the sandfish population, this survey will complete a series of five surveys since the first in 1995.

The results of the surveys showed that the three closed species, sandfish, black teatfish and surf redfish, had not recovered from their low densities observed in previous surveys. Sandfish density actually decreased to similar levels as in 1998, when the fishery was closed. While most of the decrease occurred in the juvenile sandfish population, the adult sandfish population had also declined since the previous survey in 2002. This result was quite unexpected given the relatively strong breeding cohort evident in 2002.

The information from the project has added to the developing knowledge on the population dynamics of sea cucumber populations; in particular, it has shown that depleted populations do not recover quickly. The reasons for this are still not known, however, there is likely to be some depensatory mechanisms acting on recruitment, such as dilution (or Allee) effects decreasing the fertilization success of the gametes in the water column. It is also possible that the recruitment patterns for sea cucumber populations are characterised by infrequent large recruitments. More research on this aspect of sea cucumber population biology is required to develop sustainable harvest strategies.

Conversion ratios for commercial beche-de-mer species in Torres Strait

Timothy Skewes, Louise Smith, Darren Dennis, Nick Rawlinson, Anthea Donovan, Nicholas Ellis

Source: CSIRO Marine and Atmospheric Research Report, 2004.
[http://www.afma.gov.au/research/reports/2005/r02_1195.pdf]

Survey stock weight estimates and fishery catch data from beche-de-mer fisheries can be recorded in a number of processed states from whole live to fully processed (dry). Often, these different types of weight data have to be combined and/or compared for stock assessments, for setting total allowable catches (TACs) from survey data and for catch monitoring. Accurate conversion ratios are required to complete these tasks with any confidence.

We collected suitable weight data for individual holothurians in the following states: whole live, gutted, salted, and fully processed (dry); to describe the relationships between these processed states, and to produce conversion ratios. Information for seven important commercial species was collected, included sandfish (*Holothuria scabra*), prickly redfish (*Thelenota ananas*), blackfish (*Actinopyga miliaris*), surf redfish (*A. mauritiana*), black teatfish (*H. whitmaei*), white teatfish (*H. fuscogilva*) and elephant trunkfish (*H. fuscopunctata*).

Paired weight measurements for each species were analysed to produce: 1) Regression relationships of paired processed stage data to visualise and describe the relationships between the weight of individuals at different processed stages; 2) Average recovery rates (RR), which are an indication of the overall recovery rate during processing; and 3) Conversion ratios (CR) especially designed for converting pooled catch data from one state to another.

While live weight proved to be a relatively variable weight measure for individual beche-de-mer, the average RR between live weight and gutted weight was relatively consistent between species, ranging from 52.7% to 63.8%; whereas the average RR between gutted weight and dry weight was quite variable between species, ranging from 8.4% to 25.0%. This shows that the biggest determining factor in the overall RR (live to dry) for a species is the amount of weight loss that occurs during boiling and drying of the body wall, not by the weight loss caused by gutting the live animal.

This study is a significant advancement in our understanding of conversion factors for beche-de-mer fishery and stock survey weight data in Torres Strait (and Australia), and its outputs will assist with more robust stock assessments, and in fishery management and compliance. It provides the first known data for several species, especially with respect to gutted and salted processed stages, and also in the calculation of unbiased conversion ratios for pooled fishery catch data. It will also form the basis for a complete coverage for exploited species in the future, and for investigating changes in processing technologies over time.

Long-term study of gamete release in a broadcast-spawning holothurian: Predictable lunar and diel periodicities

A. Mercier, R.H. Ycaza and J.-F. Hamel

Source: Marine Ecology Progress Series 329:179–189. (2007)

Annual and monthly patterns of gamete release by the sea cucumber *Isostichopus fuscus* on the coast of Ecuador were studied to determine the proximal spawning cue and variations in reproductive output throughout the year. Several hundred newly collected individuals were monitored nearly every month for four years. *I. fuscus* displayed a lunar spawning periodicity: 0.7–34.9% of individuals consistently spawned one to four days after the new moon. Spawning mostly occurred within one evening; however, some gamete release was often recorded over two to four consecutive evenings. Individuals maintained in captivity for several months retained their spawning periodicity and timing with the lunar cycle. Conversely, newly caught individuals that were shaded from the moonlight did not spawn, thus demonstrating the apparent lack of endogenous rhythms and prevalence of lunar luminance over other cues (i.e. tidal cycle, fluctuations in barometric pressure). On a spawning night, males typically initiated gamete release around sunset; females spawned just after the peak male broadcast. The percentage of spawning individuals was higher and a greater overlap between male and female peak spawning activity was observed during clear conditions compared with overcast conditions. The gonads of individuals that did not spawn in a given month showed a variety of maturity levels, including post-spawning, growth and mature gametogenic stages. Hence, the individual reproductive cycle is apparently longer than the monthly spawning periodicity observed at the population level, enabling *I. fuscus* populations to be reproductive year round.

Additions to the aspidochirotid, molpadid and apodid holothuroids (Echinodermata: Holothuroidea) from the east coast of southern Africa, with descriptions of new species

Thandar, A.S.

Source: Zootaxa (in press)

No abstract.

Taxonomie des holothuries des Comores

Y. Samyn, D. VandenSpiegel, C. Massin

Source: AbcTaxa Vol 1, i-iii, 130 p. (2006)

No abstract.

On a new species of *Actinopyga* Bronn, 1860 (Echinodermata, Holothuroidea) from the Indo-West Pacific

F.W.E. Rowe and C. Massin

Source: Zoosystema 28 (4): 955–961. (2006)

Actinopyga capillata n. sp., with nocturnal habits, has first been observed in the Mascarene Islands, but has a wide Indo-West Pacific distribution. The new species is clearly separated from its congeners by its colour pattern and by the presence of very long and thin dorsal tube feet. *A. capillata* n. sp. is compared with *Bohadschia mitsioensis* Cherbonnier, 1988, with which it shares similar ossicle forms.

Population dynamics of *Holothuria* (*holothuria*) *tubulosa* and *Holothuria* (*lessonothuria*) *polii* of an Algerian *Posidonia oceanica* meadow

Mezali K., Zupo V. and Francour P.

Biologica Marina Mediterranea 13(4):158–161. (2006)

Deposit-feeder holothurians represent a major component of *Posidonia oceanica* (L.) ecosystems. They actively contribute to the turnover of organic matter by ingesting materials in the detritus layer. The evolution of the biomass/density ratio was investigated for two aspidochirotid species *Holothuria* (*H.*) *tubulosa* (Gmelin, 1978) and *Holothuria* (*L.*) *polii* (Rowe, 1969). Quantitative samples were seasonally collected from March 2001 to February 2002, at 3 m depth in two Algerian contiguous shallow stations. The data collected in each season were statistically compared between stations, species and seasons. A significant difference between species was demonstrated in both stations. However, for both species, the biomass/density ratios exhibited a maximum in summer and a minimum in fall. The minimum value of the biomass/density ratio may be interpreted as an indication of recruitment. The mean abundance of *Holothuria (L.) polii* was significantly lower in the polluted station than in the unpolluted station. The data collected confirm the importance of *Holothuria (L.) polii* as an indicator of the pollution.

Small-scale fisheries for sandfish (*Holothuria scabra*)

Bell J.D., Purcell S.W. and Nash W.

Source: Naga (in press)

Severe decreases in productivity of small-scale fisheries for the valuable tropical sea cucumber, sandfish (*Holothuria scabra*), and loss of the associated traditional livelihoods, are of widespread concern. Here, we outline the role that aggregations of sandfish in no-take zones can play in replenishing local stocks, and the basic governance and social settings required to make fisheries centered around no-take zones work. We also promote rearing wild-caught sandfish in rudimentary sea pens until they reach a size of 500 g (~ 20 cm body length) as a simple way of creating protected spawning aggregations. Grow-out of juvenile wild sandfish in sea pens delivers greater benefits to fishermen and reverses the effects of fishing in open access systems, from retarding to enhancing replenishment. In particular, it creates multiple groups of spawners to help avoid the onset of Allee effects (diminished reproductive success) that can extinguish local fisheries for sandfish.

Spatio-temporal and size-dependent variation in the success of releasing cultured sea cucumbers in the wild

Purcell S.W. and Simutoga M.

Source: Reviews in Fisheries Science (in press)

Large-scale releases of cultured "sandfish" *Holothuria scabra*, were used to examine size- and density-dependent effects on survival among sites. Juveniles were marked by fluorochromes in three size classes and released into open 500-m^2 sea pens. A preliminary trial involved release of 4,000 juveniles at two sites. In a subsequent large-scale experiment, we released 9,000 juveniles at 0.5, 1 or 3 individuals m^{-2} at four sites. Growth and survival up to two years post-release were estimated from successive recapture surveys and marker verification. Most of the surviving animals attained the size at first maturity (180 g) within 12 months in the preliminary trial but grew slower in the second experiment. Growth was density dependent, with carrying capacity at one site of 200–250 g sandfish m^{-2}. Survival varied greatly among sites, explained in part by microhabitat features but site suitability was ephemeral; previous success at sites did not

guarantee success later. Juvenile size-at-release significantly affected long-term survival, but survival was density-independent within the experimental range. Juveniles should be released at a minimum size of 3 g and at multiple sites and occasions to mitigate spatio-temporal variation in survival. We predict that 7–20% of sandfish released at 3–10 g size in optimum habitat could survive to market size, which gives qualified support for restocking. Our results can also help to assess the viability of sea ranching, which will depend on sale price, harvest efficiency and reduced costs of producing juveniles.

Information on the Aspidochirote Working Group
(http://www.uog.edu/marinelab/peetcukes/index.html)

The Aspidochirote Working Group (AWG) is a team of systematists from around the world who are revising the taxonomy of aspidochirote sea cucumbers. This work is amply funded by the US National Science Foundation (NSF) under the program Partnerships for Enhancing Expertise in Taxonomy (PEET). This program aims to "support competitively reviewed research projects that target groups of poorly known organisms. This effort is designed to encourage the training of new generations of taxonomists and to translate current expertise into electronic databases and other formats with broad accessibility to the scientific community." Complementary funding to European Union members of AWG has been provided through Synthesys and the Global Taxonomy Initiative (http://www.synthesys.info/).

The diversity of our taxonomic group, the Order Aspidochirotida (Holothuroidea: Echinodermata), is highest on tropical coral reefs. There, numerous "species" are, in fact, poorly defined complexes. As a result, species diversity is grossly underestimated. Reef field guides invariably picture large, common holothuroids that do not match any known species. Reef biodiversity surveys routinely turn up undescribed species everywhere. We estimate that less than half of the reef-associated species are yet described or properly designated. Tropical aspidochirote holothuroids are, for their size, among the most poorly known marine invertebrates. The objective of this PEET project is to greatly improve our understanding of aspidochirotid systematics through large-scale cooperative efforts towards phylogenetics, monographic revisions and training.

Original text: English

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